BA Sem-I **Paper: BAP-101**
Computer Science

Fundamentals of Information Technology

UNIT No.1

Center for Distance and Online Education, PunjabiUniversity,Patiala

Lesson No:

1. **Introduction and history of computers**
2. **Classification of computers**
3. **Block diagram of computer and related terms**
4. **Input devices**
5. **Output devices**
6. **Memory**
7. **Storage devices**
8. **Computer languages**

(Syllabus)

BAP-101: Fundamentals of Information Technology

Max Marks: 60 Maximum Time: 3 Hrs.
Min Pass Marks: 35%

A) Instructions for the paper setter

The question paper will consist of three sections: A, B & C. SECTIONs A & B will have four questions each from the respective sections of the syllabus and will carry 40% marks each. SECTION C will have 6-12 short-answer type questions which will cover the entire syllabus uniformly and will carry 20% marks in all.

B) Instructions for the candidates

1. Candidates are required to attempt two questions each from the sections A & B of the question paper and the entire section C.
2. Use of non-programmable calculator is allowed.

Section - A

Computer Fundamentals: Block diagram of a computer, characteristics of computers and generations of computers. Categories of Computers - Supercomputer, mainframe computer, network server, Workstation, Desktop computers, notebook computer, Tablet PC, handheld PC, smart phone.

Input Devices: Keyboard, Mouse, Joy tick, Track Ball, Touch Screen, Light Pen, Digitizer, Scanners, Speech Recognition Devices, Optical Recognition devices – OMR, OBR, OCR

Output Devices: Monitors, Impact Printers - Dot matrix, Character and Line printer, Non Impact Printers – DeskJet and Laser printers, Plotter

Memories: Memory Hierarchy, Primary Memory – RAM, ROM, Cache memory. Secondary Storage Devices - Hard Disk, Compact Disk, DVD, Flash memory.

Software: Types of Software- System Software, Application Software, Firmware. Type of System Software: Operating Systems, Language Translators, Utility Programs, Communications Software. **Commonly Used Application Software**: Word Processor, Spreadsheet, Database, Education, Entertainment Software.

Computer Languages: Machine language, assembly language, high level language, 4GL.

Section - B

Number System: Non-positional and positional number systems, Base conversion, Concept of Bit and Byte, binary, decimal, hexadecimal, and octal

systems, conversion from one system to the other. Binary Arithmetic: Addition, subtraction and multiplication, 1's complement, 2's complement, subtraction using 1's complement and 2's complement.

Computer Codes: weighted and non-weighted code, BCD, EBCDIC, ASCIL, Unicode.

Computer Network: Network types, network topologies.

Internet Related Concepts: Internet, World Wide Web, Hypertext, Uniform Resource Locator, Web Browsers, IP Address, Domain Name, Internet Services Providers, Internet Security, Web Search Engine, Net Surfing, web portal, Wiki, Blog.

Advanced Trends in IT : Mobile Technology, Internet, GPS, 3G, 4G, Wi-Fi, Bluetooth, Cloud Virtual LAN Technology, Firewall, E-Commerce, M-Commerce, Nanotechnology, Virtual Reality, BPO and KPO, Online shopping, Social Media - FaceBook, Linkedin, Twitter, YouTube, Google+.

Applications of IT: IT in Business and Industry, IT in Education & training, IT in Science and Technology, IT and Entertainment, Current Trends in IT Application - AL, Virtual Reports, voice recognition, Robots, Multimedia Technology.

Reference Books:

1. Peter Nortorn, Introduction to Computers, Seventh Edition
2. V. Rajaraman, Fundamentals of Computers, PHI.
3. Larry E. Long and Nancy Long, Computers: Information Technology in Perspective, PHI
4. N. Subramanian, Introduction to Computers, Tata McGraw-Hill.
5. D.H. Sanders, Computers Today, McGraw- Hill.

LESSON NO. 1 **AUTHOR: JAGMOHAN SINGH JUNEJA**
Converted into SLM by: Dr. Vishal Singh

INTRODUCTION AND HISTORY OF COMPUTERS

1. Objectives

Main objectives of this lesson are to understand the various historical developments in the areas of computations and computers. To classify the development of computers into different generations.

2. Introduction

In the contemporary age of Information Technology, computers are used as an ultimate initiation point pertaining to creating, managing, processing and exchanging information. Its charisma can be found in almost in all walks of life such as education, communication, entertainment, banking, business, medicine, weather forecasting, scientific research, defense, transport reservation systems, etc.

3. What is Computer?

A computer is a programmable machine that receives input, stores and manipulates data and provides output in a useful format or we can say a computer is an information-processing machine. It can perform arithmetic operations (Addition, Subtraction, Multiplication and Division

etc.) and it can take logical decisions. It has a memory and can store lot of information. The stored information may be retrieved, moved and operated upon as desired. Computations are done at an extremely fast speed with complete reliability and accuracy.

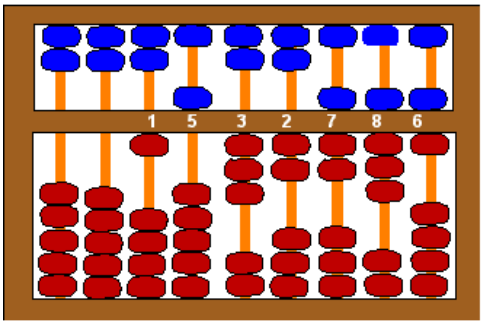
A computer can do some work only when it is supplied with instructions and required data. Without proper instructions or commands, it just cannot do anything. It does exactly what it is instructed to do, nothing more and nothing less. It has not any thinking power, but only 'obeying' power. We communicate with a computer with the help of Input/Output devices.

4. History and Generations of Computers

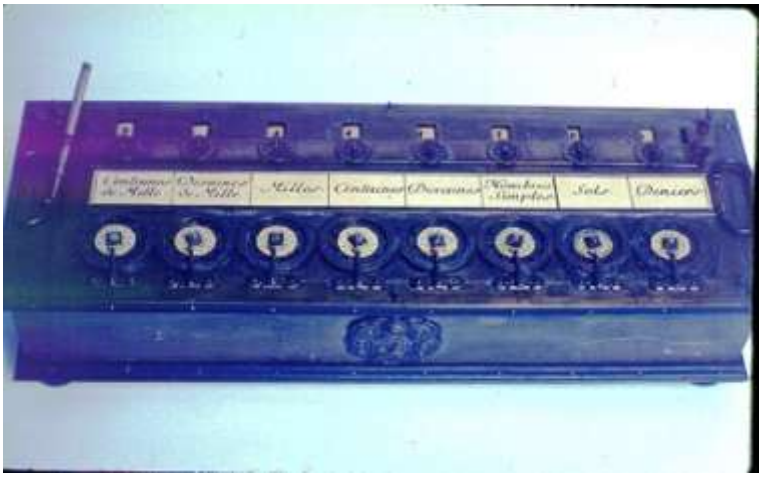
4.1 History of Computers

4.1.1 Early Developments

Man has been interested in counting since ages. The earliest counting devise was the ***Abacus***. It was developed sometime between 1000 and 400 B.C. The Abacus is essentially a collection of beads strung on parallel rods fixed in a frame. There are two portions. The beads in the upper portion count five each and those in the lower portion count one each. Arithmetic calculations are performed by manipulating these beads.



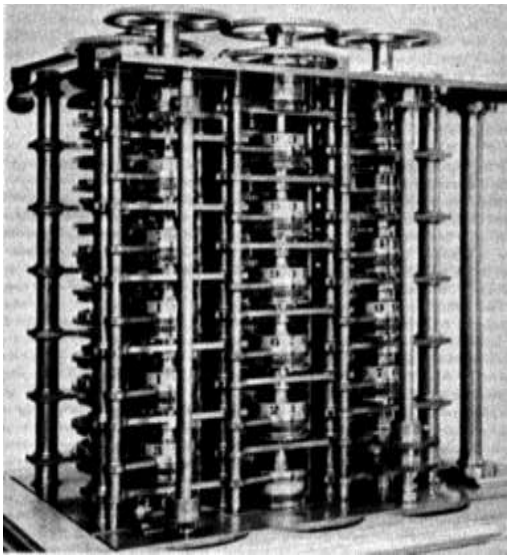
Significant developments in counting devices took place around 1640, when **Blasie Pascal**, a Young French Mathematician, invented a ***simple adding machine***. It consists of a series of toothed wheels.

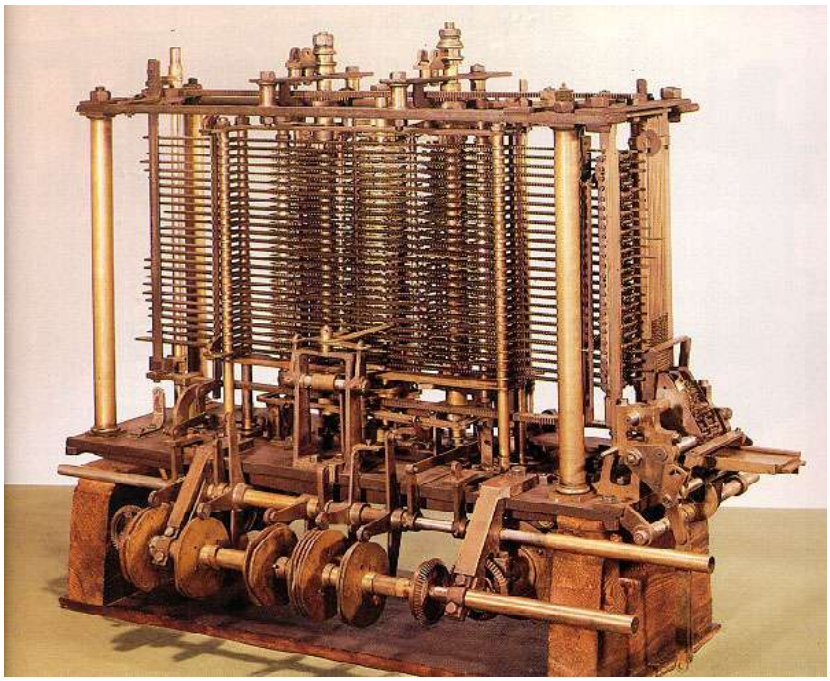


There were ten teeth on each wheel. These represented digits from 0 to 9A. When a wheel was rotated past 9, a small indicator on one wheel caused the next wheel to rotate automatically. This way, when one wheel turned past digit 9, it exchanged its ten teeth for one

tooth on the next wheel. Pascal's machine could perform additions. It was later improved upon by Leibnitz, a German mathematician whose machine could perform multiplications and divisions as well.

Charles Babbage, an English mathematician, developed a mechanical calculating device, called ***Difference Engine*** for automatic computation of mathematical tables around 1830. Babbage was also involved in the design of another calculating machine which could perform many general functions in an automatic way. After much effort, he constructed a machine called ***Analytical Engine***. This machine had a memory device, an arithmetic device, a punched card input system and an external memory store. Thus, Babbage's analytical engine had many of the same fundamental features as the modern computers about which you will learn in the next lesson. However, the analytical and difference engines were never produced commercially.





This was because of the lack of manufacturing technology at that time. But Babbage is considered one of the great pioneers in the field of computation for his foresight to design the analytical engine.

These were all mechanical machines and their reliability was rather poor. **Nevertheless, they laid the basis for the development of advanced calculating machines for the future.**

4.2 Generations of Computers

Several types of computers, having wide range of characteristics have been designed. The design, speed, size and performance of computers have been changing continuously. Due to this, it has become customary to divide the computer systems into what have come to be known as “Generations”. A major technological development that fundamentally changed the way computers operate, resulting in increasingly smaller, cheaper, more powerful and more efficient and reliable devices characterize each generation of computer. Broadly speaking, following are the generations of the computers.

4.2 .1 First generation

Computers designed during the period 1940-55 are generally termed as first generation computers. The computers of this generation used vacuum tubes for circuitry and magnetic drums for memory and were often enormous and bulky, taking up entire rooms.

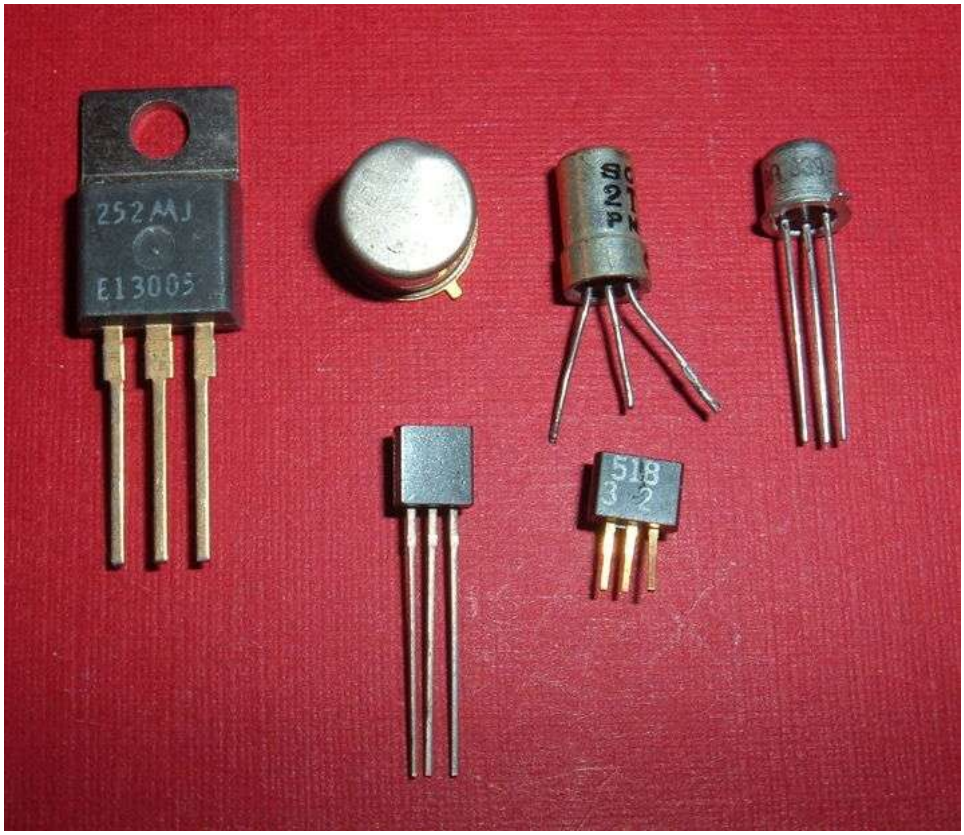
They were very expensive to operate and in addition to using a great deal of electricity, generated a lot of heat, which was often the cause of malfunctions. First generation computers relied on machine language to perform operations and they could only solve one problem at a

time. Their memory was limited and used punched card and punched paper tape for input and output of data. These machines used low level programming languages and involved manual controls. They were special purpose machines. Their operating systems were primitive (Operating system is a collection of programs supplied by the manufacturers. It helps to reduce the human intervention and increase the efficiency of the computer.)

ENIAC (Electronic Numerical Integrator and Calculator), EDSAC (Electronic Delayed Storage Automatic Computer), UNIVAC I (Universal Automatic Computer), IBM 650 are the examples of first generation computers.

4.2 .2 Second generation

The second-generation computers (1956-1963) are characterized by their use of tiny transistors. Transistors replaced vacuum tubes and ushered in the second generation of computers. The transistor was invented in 1947 but did not see widespread use in computers until the late 50s.



The transistor was far superior to the vacuum tube, allowing computers to become smaller, faster, cheaper, more energy-efficient and more reliable than their first-generation predecessors. They required less power to operate. They were much more reliable as compared to the first generation computers. Though the transistor still generated a great deal of heat that subjected the computer to damage, it was a vast improvement over the vacuum

tube. Second-generation computers still relied on punched cards and paper tapes for input and printouts for output.

Second-generation computers moved from cryptic binary machine language to symbolic, or assembly, languages, which allowed programmers to specify instructions in words. High-level programming languages were also being developed at this time, such as early versions of COBOL and FORTRAN. These were also the first computers that stored the instructions in memory, which moved from a magnetic drum to magnetic core technology.

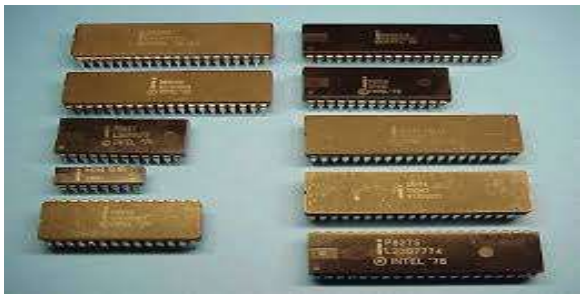
Second generation computers had more speed (about 10^6 operations per second), larger memory and faster Input/Output devices.

The second-generation computers span spreads over the years 1960-65. Several companies started manufacturing computers. Systems were designed for special applications, for business and scientific data processing.

IBM 1401, IBM 7090/7094 series, IBM 1620, Burroughs B5000, CDC 1640, GE 635, Honeywell 400 series, UNIVAC III and several others are the examples of second-generation computers.

4.2 .3 Third Generation

The third Generation computers (1964-75) used integrated circuits (electronic circuits designed on silicon chips) instead of transistors. The development of the integrated circuit was the hallmark of the third generation of computers. Transistors were miniaturized and placed on silicon chips, called semiconductors, which drastically increased the speed and efficiency of computers. The size of such circuits was hundreds times smaller than the transistor circuit size. Moreover, the associated electronic circuitry was also reduced in dimensions many times.



This leads to several advantages:

(I) small size and increased processing speed (~10^8 operations/ second)

(ii) more reliability and higher accuracy

(iii) easy maintenance and simple repair requirements.

Moreover, these machines had very large storage capacity, faster and more versatile Input/Output devices. Instead of punched cards and paper tapes, users interacted with third generation computers through keyboards and monitors. These computers were interfaced with highly sophisticated operating system, application software, and packages, which allowed the device to run many different applications at one time with a central program that, monitored the memory. Computers for the first time became accessible to a mass audience because they were smaller and cheaper than their predecessors. Video display, graphic terminals, plotters, magnetic disks, drums, tapes etc. may be used with them.

Third generation computers were mostly general purpose, that is, they may be used for processing business, scientific or text oriented problems. Some examples of third generation

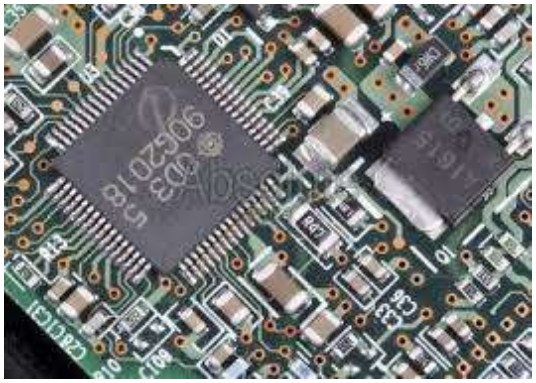
computers are IBM 360 series, Burroughs 6700/7700 series, CDC 6000/7000 series, Digital Equipment PDP-8/11 series, UNIVAC 1108/9 series, ICL 1900/2900 series, and so on.

4.2 .4 Fourth Generation

First Decade (1976-85)

The microprocessor brought the fourth generation of computers, as thousands of integrated circuits were built onto a single silicon chip. What in the first generation filled an entire room could now fit in the palm of the hand. The Intel 4004 chip, located all the components of the computer - from the central processing unit and memory to input/output controls - on a single chip.

The fourth generation may be identified by the advent of the microprocessor chip. Medium scale integrated circuits yielded to Large and Very Large Scale Integrated circuits (VLSI) packing about 50000 transistors in a chip. Magnetic core memories were replaced by semiconductor memories. Semiconductor memory size of 16 Megabytes with a cycle time of 200 nsecs were in common use. The emergence of the microprocessor led to two directions in computer development. One direction was the emergence of extremely powerful personal computers. Computer cost came down so rapidly that professionals had their own computer to use in their office and home. Hard disks provided a low cost, high capacity secondary memory.



The other direction of development was the decentralization of computer organization. Individual microprocessor controls for terminals and peripheral devices allowed the CPU to concentrate on processing the main program. Networks of computers and distributed computer systems were developed. Disk memories became very large (1000 Mbytes/drive). A significant development in software was the development of concurrent programming languages. Such languages are important to program distributed systems and real time systems. The most ambitious language of this type was ADA. Another important development was interactive graphic devices and language interfaces to graphic systems. The emergence of graphics gave a great impetus to computer aided engineering design.

Fourth generation saw the coming of age of UNIX OS and time shared interactive systems. These systems became user friendly and highly reliable. The effective cost of computing came down. In 1981 IBM introduced its first computer for the home user, and in 1984 Apple introduced the Macintosh.

Second Decade (1986-1995)

The second decade of the fourth generation has seen a relentless increase in the speed of microprocessors and the size of main memory. The speed of microprocessors and the size of

main memory and hard disk went up by a factor of 4 every 3 years. Many of the features originally found in CPU of large expensive mainframe computers of the first decade of the fourth generation became part of the microprocessor architecture in the 90s. Thus the mainframe computer of early 80s died in mid 90s. The alpha microprocessor chip designed by DEC in 1994 packed 9A.3 million transistors in a single chip, was driven by a 300 MHZ clock and could carry out a billion operations per second. It had a built in 64 bit floating point arithmetic unit, used 64 bit address buses. It has built in cache memory of 64KB and 32 registers to store temporary operands. Apart from this IBM, Apple computers and Motorola co-operated in designing a microprocessor called Power PC 600 series. Intel also designed a powerful chip in 90s called Pentium (1993) which sold in large numbers.

Microprocessors such as Pentium, Power PC, etc., are being used as the CPU of portable laptop and palm held computers (1995). Personal Computer, Desk to workstations and powerful servers for numeric computing as well as services use RISC microprocessors such as Alpha, MIPS and SUNSPARC.

The area of hard disk storage also saw vast improvements. 1 GB of disk on workstations became common in 1994. For larger disks RAID technology (Redundant Array of Inexpensive Disks) was used to give storage of 100 GB. During the decade optical disks emerged as mass storage particularly for read only files.

Optical storage sizes were of order of 600MB on a 5.25 disk. The availability of optical disks at low cost saw the emergence of multimedia applications. Multimedia workstations emerged as widely used systems.

Computer Networks came of age. The networks become very powerful with the advent of fibre optic Local Area Networks which could transmit 100MB/sec. to 1 GB/sec. Mainframes were replaced by powerful workstations connected by fibre optic network.

In the area of languages C language became popular. This was followed by a new method of design called Object Oriented Design. The primary objectives of Object Oriented Design are to generalize programs and to reuse objects. The C++ language emerged as the most popular Object Oriented Language. One also saw a trend towards design of specification oriented languages. PROLOG was designed for Logic Oriented Specification Language. With the emergence of distributed computers connected by networks considerable effort has gone into programming distributed systems. A number of parallel computers were built but no commonly accepted standard parallel programming language emerged.

Microprocessors also moved out of the realm of desktop computers and into many areas of life as more and more everyday products began to use microprocessors.

As these small computers became more powerful, they could be linked together to form networks, which eventually led to the development of the Internet. Fourth generation computers also saw the development of GUIs, the mouse and handheld devices.

Main Characteristics of First four Generations have been shown in the following Table

Generation	Years	Switching device	Storage device	Switching time	MTBF*	Software	Applications
First	1940-55	Vacuum tubes	Acoustic delay lines and later magnetic drum. 1kbyte memory.	0.1 to 1 millisecond	30 mts. to 1 hour	Machine languages and Simple monitoring software	Mostly scientific. Later simple business applications
Second	1956-63	Transistors	Magnetic core main memory, tapes and disk peripheral memory. 100 Kbyte main memory.	1 to 10 microseconds	About 10 hrs.	Symbolic and assembly languages. Early version of rsHigh level languages FORTRAN, COBOL, Algol, Batch operating systems.	Extensive business applications. Engineering design optimization, scientific research.
Third	1964-75	Integrated Circuits (IC)	High speed magnetic cores. Large disks (100 MB). 1 Mbyte main memory.	0.1 to 1 micro-second	About 100 hrs.	FORTRAN IV, COBOL 68. PL/1, Timeshared operating system.	Data base management systems. On line systems.
Fourth--First decade	1976-85	Large scale inte-grated circuits. Micro-processors (LSI)	Semiconductor memory. Winchchester disk. 10Mbyte main memory. 1000 Mbyte disks.	10 to 100 nano-seconds	About 1000 hrs.	FORTRAN 77, Pascal, ADA, COBOL-74, Concur-rent Pascal.	Personal computers. Distributed systems. Integrated CAD/CAM Real time control. Graphics oriented systems.
Fourth--Second decade	1986-1995	Very large scale integrated circuits. Over 3 million transistors	Semiconductor memory. IGB main memory. 100 GB disk.	1 to 10 nano-seconds.	About 10,000 hrs.	C, C++,. JAVA, PROLOG	Simulation, Visual-ization, Parallel computing, Virtual reality, Multimedia.

		per chip					

4.2 .5 Fifth Generation - Present and Beyond

Presently “Super Large Scale Integrated Circuits” chips technology is being used. Today’s microprocessors are having million of electronic circuits on one small chip. As a result of this now computers have become very compact, very cheap, much more powerful and reliable. With the advent of new technologies Desktop Personal Computers, Workstations and Laptops with multimedia capabilities have become very popular. These are coming with dual core and core 2 duo processors. Present computers are very powerful with respect to Processor speed, Primary and Secondary storage capacities, Sophisticated Input/output devices and multimedia capabilities. Detailed configuration, Input - Output devices, other peripherals and other features have been discussed in later lessons.

Fifth generation computing devices, based on artificial intelligence (Normally abbreviated as AI), are still in development, though there are some applications, such as voice recognition, that are being used today. The use of parallel processing and superconductors is helping to make artificial intelligence a reality. Quantum computation and molecular and nanotechnology will radically change the face of computers in years to come. The goal of fifth-generation computing is to develop devices that respond to natural language input, graphic images, voice recognitions, human expressions etc. and are capable of learning and self-organization.These computers will be based on NLP – Natural Language Processing and biometric techniques. These computers will use intelligent programming (artificial intelligence)and knowledge based problem solving techniques. The conventional data processing is based on processing information whereas artificial intelligence deals with processing ideas and knowledge.

5. Summary

Many devices such as Abacus, Mechanical Adding machine and Mechanical Difference Engine etc. were developed by the man for his computing requirements before the development of computers. **Charles Babbage**, an English mathematician, constructed a machine called **Analytical Engine**. This machine had a memory device, an arithmetic device, a punched card input system and an external memory store. Babbage’s analytical engine had many of the same fundamental features as the modern computers have. **Charles Babbage** was the first scientist to propose the idea of programmable computer. Therefore Babbage is considered one of the great pioneers in the field of computation for his foresight to design the analytical engine. **Babbage laid the basis for the development of advanced calculating machines for the future.** Some of the early computer such as MARK –I, ENIAC, EDSAC and UNIVAC etc. are considered as the stepping stones for the development of modern computers.

Development of computers has been divided into five generations, primarily on the basis of major technological changes due to which there were significant changes in size, price, efficiency, reliability and storage capacity etc. First generation computers (1940-1955) used vacuum tubes. These computers were very large, required lot of space, generated lot of heat,

very slow and very less reliable. Second-generation computers (1956-1963) used transistors instead of vacuum tubes. The transistor was far superior to the vacuum tube, allowing computers to become smaller, faster, cheaper, more energy-efficient and more reliable than their first-generation predecessors. They required less power to operate. They were much more reliable as compared to the first generation computers. The third Generation computers (1964-75) used integrated circuits (electronic circuits designed on silicon chips) instead of transistors. The development of the integrated circuit was the hallmark of the third generation of computers. This development made computers smaller in size, more reliable, more efficient and much cheaper. These machines had very large storage capacity, faster and more versatile Input/Output devices. Third generation computers were mostly general purpose computers, Fourth generation computer used microprocessors having thousands of integrated circuits onto a single silicon chip. These computer were very powerful, compact, reliable and affordable. Fifth generation computers, based on artificial intelligence (Normally abbreviated as AI), are still in development stage. They are using “Super Large Scale Integrated Circuits” chips technology. Now a days microprocessors are having million of electronic circuits on one small chip. The goal of fifth-generation computing is to develop devices that respond to natural language input, graphic images, voice recognitions, human expressions etc. and are capable of learning and self-organization. These computers will be based on NLP – Natural Language Processing and biometric techniques. These computers will use intelligent programming (artificial intelligence) and knowledge based problem solving techniques.

6. Keywords

Computer	Computer is an information-processing machine, which can perform arithmetic operations (Addition, Subtraction, Multiplication and Division etc.) and which can take logical decisions having memory and capability to store information and instructions.
Abacus	The earliest counting devise, which was developed sometime between 1000 and 400 B.C. It is a collection of beads strung on parallel rods fixed in a frame. Arithmetic calculations are performed by manipulating these beads.

Analytical Engine	**Charles Babbage,** constructed this machine, which had memory device, an arithmetic device, a punched card input system and an external memory store. This analytical engine had many of the same fundamental features as the modern computers have.
Generations of Computers/ Computer Generations	Development of computers has been divided into five generations, primarily on the basis of major technological changes due to which there were significant changes in size, price, efficiency, reliability and storage capacity etc.
ENIAC	Electronic Numerical Integrator and Calculator
EDSAC	Electronic Delayed Storage Automatic Computer
UNIVAC	Universal Automatic Computer

7. Short answer type Questions

1. What is a Computer?
2. Write the name of technology used for each generation.
3. Write the full form of the following abbreviations
   - ENIAC
   - EDSAC
   - UNIVAC
   - AI
   - IBM
   - CDC
   - GE

8. Long answer type Questions

1. Describe the different generations of computers along with the major technology used and advantages/disadvantages for each generation.
2. Trace the history of development of computers.

9. Suggested Readings

- Information Technology by Satish Jain
- Information Technology and Management by Turban Mclean and Wetbrete
- Computer Fundamentals by Pradeep Kumar Sinha and Priti Sinha
- Fundamentals of Computer by V.Rajaraman, PHI, India.

LESSON NO. 2 **AUTHOR: JAGMOHAN SINGH JUNEJA**
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CLASSIFICATION OF COMPUTERS

1. Objectives

Objective of this lesson is to classify the computers on the basis of historical development of computers (Five generations), Classification according to purpose (General and Specific), classification according to type of data- techniques (Analog Computers, Digital Computers, Hybrid computers) and Classification according to functionality (Micro computers, Mini computers, Mainframes, Super computers)

2. Introduction

In the contemporary age of Information Technology, computers are used as an ultimate initiation point pertaining to creating, managing, processing and exchanging information. Its charisma can be found in almost in all walks of life such as education, communication, entertainment, banking, business, medicine, weather forecasting, scientific research, defense, transport reservation systems, etc.

3. Computer

Computer can be described as an information-processing machine which can perform arithmetic operations (Addition, Subtraction, Multiplication and Division etc.) and which can take logical decisions. It has the capability to store lot of information and instructions in the memory. The stored information can be retrieved, moved and operated upon as desired. Computations are done at an extremely fast speed with complete reliability and accuracy.

4. Classifications of Computers

These days, computers are available in many sizes and types. One can have a computer that can fit in the palm to those which can occupy the space of entire room. Computers can be classified on the basis of many factors and criterion such as historical development, Physical size, Performance, Application areas, Data processing abilities etc.

4.1 Classification due to historical development of computers

On the basis of historical development, computers are classified into five generations. These generations are explained in details in lesson no. 1.

4.2 Classification according to purpose

Computers are designed for different purposes. They can be used either for general purposes or for some specific purpose.

General purpose computers

A general purpose computer, as the name suggests, is designed to perform a range of tasks. These computers have the ability to store numerous programs. These machines can be used for various applications ranging from scientific as well as business purpose applications. Even though such computers are versatile, they generally lack in speed and efficiency. Normally general purpose computers are used by the common man, institutions and business applications. Normally, when we talk about computer, it means general purpose digital computer.

Specific purpose computers

These computers are designed to handle specific type of applications, normally a single specific task. A set of instructions for the specific task is built into the machine. Hence these cannot be used for other applications. Therefore these lacked in versatility. However, being designed for specific tasks, they can provide the result very quickly and efficiently. ATM machines, Election voting machines, Image processing machines, Satellite tracking machines etc. are some of the examples of such type of computers.

4.3 Classification according to type of data-handled techniques

According to the basic data handling principle, computers can be classified into following three types of categories

1. Analog Computers
2. Digital Computers
3. Hybrid computers

4.3.1 Analog Computers

An analog computer (spelled analogue in British English) is a form of computer that uses electrical, mechanical or hydraulic phenomena to model the problem being solved. More generally an analog computer uses one kind of physical quantity to represent the behavior of another physical system or mathematical function. Analog computer accepts, processes and generates continuous data. Computations are carried out with physical quantities such as length, voltage, current etc. Slide rule, voltmeter, ammeter, potentiometer, thermometer are the examples of analog devices. When current is passed through ammeter, it gives information about current passing through it. The deflection in the needle indicates the amount of current passing. Deflection is more for higher current and less for lower current. Current (input) and deflection (output) are both continuous quantities. Analog computers are usually slow and less accurate. They are designed for special applications. Analog computers comprise of mechanical parts to solve the problem.

4.3.2 Digital Computers

Digital computer accepts, processes and generates discrete data (discontinuous data). Computations are done with discrete quantities, such as numerical digits. Usual facit machines (mechanical calculating machine), electronic calculators are the digital devices. A computer that stores data in terms of digits (numbers) and proceeds in discrete steps from one state to the next. The states of a digital computer typically involve binary digits. In digital computers letters, words, whole texts, pictures and graphics etc. are represented digitally.

Digital computers calculate by manipulating binary digits (bits; ones and zeroes). Because bits are so simple to handle they can be made easily to stand for almost anything; hence the general usefulness of digital computers. Bits can symbolize words, instructions, laws of logic or of physics, numerical measurements, recorded images and sounds--anything that can be written down.

Normally digital computers are much faster than analog computers and computations are much more accurate. They come in various sizes – starting from pocket size to large systems. All personal computers are digital. Digital computers can be designed for special or for general purpose.

4.3.3 Hybrid computers

Hybrid computers are computers that comprise features of analog computers and digital computers. The digital component normally serves as the controller and provides logical operations, while the analog component normally serves as a solver of differential equations. Hybrid computers find applications in special areas only.

Normally, when we speak of a computer, it means digital computer unless otherwise it is mentioned.

4.4 Classification according to functionality

Based on the physical size, performance and application areas, computers are classified into the following four major categories

- Micro computers
- Mini computers
- Mainframes
- Super computers

Manufacturers design a vast range of computers, Input/Output devices and software to meet different requirements of users. Computers come in various sizes. We speak of Micro, Mini, Large, Super Computers and so on. These terms are convenient but not precise.

4.4.1 Micro computers

Amicro computer is a small, low cost digital computer. These computers use a microprocessor chip. These computers are also called personal computers. Initially these are used at homes or by the individuals but now a days these have become very powerful with respect to Processor speed, Primary and Secondary storage capacities, Sophisticated Input/Output devices and multimedia capabilities. Now these are being used in large by the business houses and institutions. Major types of micro computers are Laptop, Desktop and Palmtop.

These have been discussed in detail in next lessons.

4.4.2 Mini computers

The term minicomputer originated in 1960s when it was realized that many computing tasks do not require an expensive contemporary mainframe computers but can be solved by a small, inexpensive computer. Initial minicomputers were 8 bit and 12 bit machines but by 1970's almost all minicomputers were 16 bit machines. The 16 bit minicomputers have the advantage of large instruction set and address field; and efficient storage and handling of text, in comparison to lower bit machines. Thus, 16 bit minicomputer was more powerful machine which could be used in variety of applications and could support business applications alongwith the scientific applications.

With the advancement in technology the speed, memory size and other characteristics developed and the minicomputer was then used for various stand alone or dedicated applications. The minicomputer was then used as a multi-user system, which can be used by various users at the same time. Gradually the architectural requirement of minicomputers grew and a 32-bit minicomputer, which was called super mini was introduced. The super mini had more peripheral devices, larger memory and could support more users working simultaneously on the computer in comparison to previous minicomputers.

These are powerful computers. These computers come into existence in 1960s at that time mainframe computer was very costly. Mini computers were available in cheap prices, so users start using it. Mini computers are far ahead in speed when compared to micros. They vary in size from a desk top model to a small file cabinet. They are generally used to cater the needs of multiple users simultaneously. Normally they are used for the following purposes

- Business & industry usage
- Multiple users
- Specified tasks

4.4.3 Mainframes

Mainframe computers are generally 32-bit machines or on the higher side. These are suited to big organisations, to manage high volume applications. Few of popular mainframe series are MEDHA, Sperry, DEC, IBM, HP, ICL, etc. Mainframes are also used as central host computers in distributed systems. Libraries of application programs developed for mainframe computers are much larger than those of the micro or minicomputers because of their evolution over several decades as families of computing. All these factors and many more make the mainframe computers indispensable even with the popularity of microcomputers. Mainframes as, the name implies are used on a large scale jobs in organizations and factories. They have enormous storage and other special capabilities. They vary in sizes and performances. They are expensive, but larger, quicker and smarter than their counterparts. Mainframe computers are used when you access your bank account from a automated teller. The bank's mainframes handle all the transactions. A mainframe is a computer that can process and store large amounts of information and support many users at the same time. They can handle processing of many users at a time. Terminals are used to connect a user to this computer and users submit their task through mainframe. Terminal is a device which has keyboard and a screen. By using terminal users put inputs into the computer and get the output through screen. A small mainframe computer might be a rack of equipment about eight feet tall and ten to twenty feet long. It is kept in a special room with heavy air conditioning. One of the biggest mainframe computers are those at an IRS regional office. They take up many rooms and have hundreds of terminals, tape stands and disk drives.

4.4.4 Super computers

The upper end of the state of the art mainframe machine is the supercomputers. These are amongst the fastest machines in terms of processing speed and use multiprocessing techniques, where a number of processors are used to solve a problem. There are a number of manufacturers who dominate the market of supercomputers-CRAY (CRAY YMP, CRAY 2). ETA (CDC-ETA 10, ETA 20) and IBM 3090 (with vector), NEC (NEC SX-3), Fujitsu (VP Series) and HITACHI (S Series) are some of them. Lately ranges of parallel computing products, which are multiprocessors sharing common buses, have been in use in combination with the mainframe supercomputers. The supercomputers are reaching up to speeds well over 25000 million arithmetic operations per second. India has also announced its indigenous supercomputer. As the name "Super Computer" specifies that these are most powerful computers even than mainframe. Actually, when we optimize a mainframe computer then we get super computer. A special class of computers designed to do high speed processing are the super computers. They were the first computers to do a 24-hr weather forecast in less than 25 hours. They work best of weather forecasting and other types of computing where many calculations can be done in parallel. Super computers belong to the pinnacle of this

classification. They are the best in the business. They can perform billions of calculations in an instant. Supercomputers are mainly being used for number crunching problems such as weather forecasting, computational fluid dynamics, remote sensing, image processing, aircraft designing, biomedical applications, etc. In India, we have one such mainframe supercomputer system-CRAY XMP-14, which is at present, being used by Meteorological Department.

5. Summary

In the contemporary age of Information Technology, computers are used as an ultimate initiation point pertaining to creating, managing, processing and exchanging information. Computer can be described as an information-processing machine which can perform arithmetic operations (Addition, Subtraction, Multiplication and Division etc.) and which can take logical decisions. Computers can be classified on the basis of many factors such as **Classification due to historical development of computers -** On the basis of historical development, computers are classified into five generations, **Classification according to purpose -** Computers can be used either for general purposes or for some specific purpose. **Classification according to type of data-handled techniques -** According to the basic data handling principle, computers can be classified into Analog, Digital and Hybrid computers. Analog computer accepts, processes and generates continuous data. Digital computer accepts, processes and generates discrete data (discontinuous data). Hybrid computers are computers that comprise features of analog computers and digital computers. **Classification according to functionality -** Based on the physical size, performance and application areas, computers are classified into the four major categories, viz Micro computers, Mini computers, Mainframes, Super computers. Amicro computer is a small, low cost digital computer. These computers use a microprocessor chip. Minicomputer originated in 1960s when it was realized that many computing tasks do not require an expensive contemporary mainframe computers but can be solved by a small. The 16 bit minicomputers have the advantage of large instruction set and address field; and efficient storage and handling of text, in comparison to lower bit machines. Mainframe computers are generally 32-bit machines or on the higher side. These are suited to big organisations, to manage high volume applications. Few of popular mainframe series are MEDHA, Sperry, DEC, IBM, HP, ICL, etc. The upper end of the state of the art mainframe machine is the supercomputers. These are amongst the fastest machines in terms of processing speed and use multiprocessing techniques,

6. Keywords

ANOLOG COMPUTER	Analog computer accepts, processes and generates continuous data.
DIGITAL COMPUTER	Digital computer accepts, processes and generates discrete data (discontinuous data).
HYBRID COMPUTER	Hybrid computers are computers that comprise features of analog computers and digital computers.
MICRO COMPUTERS	Amicro computer is a small, low cost digital computer. These computers use a microprocessor chip.

MINI COMPUTERS	Minicomputer originated in 1960s when it was realized that many computing tasks do not require an expensive contemporary mainframe computers but can be solved by a small. The 16 bit minicomputers have the advantage of large instruction set and address field; and efficient storage and handling of text, in comparison to lower bit machines.
MAINFRAMES COMPUTERS	Mainframe computers are generally 32-bit machines or on the higher side. These are suited to big organisations, to manage high volume applications. Few of popular mainframe series are MEDHA, Sperry, DEC, IBM, HP, ICL, etc.
SUPER COMPUTERS	The upper end of the state of the art mainframe machine is the supercomputers. These are amongst the fastest machines in terms of processing speed and use multiprocessing techniques,

7. Short answer type Questions

1. Classify the computers on the basis of historical development of computers
2. Classify the computers according to purpose.
3. Classify the computers according to type of data-handled techniques.
4. Classify the computers according to functionality.

8. Long answer type Questions

1. What is the difference between analog, digital and hybrid computers?
2. Describe some of the feature of Supper computers, Mainframe, Mini and Micro Computers
3. Explain the various classifications of computers.

9. Suggested Readings

- Information Technology by Satish Jain
- Information Technology and Management by Turban Mclean and Wetbrete
- Computer Fundamentals by Pradeep Kumar Sinha and Priti Sinha
- Fundamentals of Computers by V.Rajaraman, PHI, India.

LESSON NO. 3 **AUTHOR: JAGMOHAN SINGH JUNEJA**
Converted into SLM by: Dr. Vishal Singh

BLOCK DIAGRAM OF COMPUTER AND RELATED TERMS

1. Objectives

Objectives of this lesson are to describe the benefits, characteristics and limitations of computers. To know the function of Arithmetic and Logical Unit (ALU); Control Unit (CU) and Main Memory Unit (MMU).

2. Introduction

In the contemporary age of Information Technology, computers are used as an ultimate initiation point pertaining to creating, managing, processing and exchanging information. Its charisma can be found in almost in all walks of life such as education, communication, entertainment, banking, business, medicine, weather forecasting, scientific research, defense, transport reservation systems, etc.

Undoubtedly, computers are powerful tools, which can be used to perform a wide range of functions. But they ask for clear and complete instructions to perform a task comprehensively. That is why; use of computer is subjugated to the skills of its user. Dexterity is directly

proportional to practice it and rehearsals. Minor distortions can lead to complete malfunctioning of this basic time and effort saving techno-service.

High speed processing, accuracy maintained by it, massive storage capabilities, diligence, versatility in its usage and cost effectiveness are the bare minimum benefits. These can be easily approved to be in conjugal relationships while using Computers for any job.

When computers were first introduced in India, cost and maintenance involved allowed a limited number of institutions to afford computers. Only the top-of-the-line educational institutions, such as the Indian Institute of Technology and the Indian Institute of Management (IITs and IIMs), had a computer laboratory. In addition to these, only government sponsored research laboratories, such as Indian Space Research Organization (ISRO) and Bhaba Atomic Research Centre were able to afford them. In the late 1980s, the country witnessed a sweeping change.

There is an escalating trend towards the usage of Computers in our daily life. Portability, owing to its small size and huge processing and storage capacity has made it very popular. Easy to use graphical user interface, reusable software and robust operating environments is the second critical factor, which adds to the success story of usage of computers. Introduction of the computers into even kindergarten curriculum is also an escalating factor in the popularization of this machine.

A computer is composed of hardware and software, and can exist in a variety of sizes and configurations : Personal Computer, Workstation, Minicomputer, Main-frame, Supercomputer.

3. Computer

Computer can be described as an information-processing machine which can perform arithmetic operations (Addition, Subtraction, Multiplication and Division etc.) and which can take logical decisions. It has the capability to store lot of information and instructions in the memory. The stored information can be retrieved, moved and operated upon as desired. Computations are done at an extremely fast speed with complete reliability and accuracy.

4. Benefits of Computers

A Computer is an intelligent amplifier that performs the operations in a more faster, accurate and efficient way as compared to humans. Thus, it frees humans to use their time in matters involving creativity & Judgment.

The benefits are listed as below:

A Computer can add, subtract, multiply and divide numbers, compare letters to determine alphabetic sequence, move and copy numbers and letters with significant speed. This speed varies from a few microseconds (millionth of a second) to nanosecond (billionth of second). For instance, a small computer can evaluate investment decisions by performing hundreds of thousands of machine operations in a second. Number crunching at tremendous processing speed and that too with lot of accuracy is simply guaranteed with the use of computers.

Computers are very accurate. They can perform hundreds of thousands of operations with great accuracy as their circuits have no mechanical parts to wear and malfunction. They can run errorless for days, at a time.

Computer output is generally very reliable, subject to the condition that the input data entering the computer should be correct and the program of instructions should be reliable and correct. Because various computer media can store millions of characters of data in a condensed form, there is a tremendous savings in the storage area required to maintain the vital records necessary in a business environment.

Computers are used for official and home use i.e you can write papers on it, download music, play games and compose e-mail, instant message friends on it. It is a tool for all things high-tech and a staple of the college student's life. Computer can also help take care of simple tasks that are easy to do i.e. your computer can wake you up in the morning, tell you when a test is, make a long-distance phone call for you and even keep in touch with friends through video. It is much more than a program to check e-mail. If you want to take the time, Outlook can keep up with all your test times, homework assignments and various dates of high importance. An easy-to-navigate planner also allows effortless setup of recurring appointments. You can also keep in touch with friends using a webcam with computer. It is this diligence and its versatility that makes computers a robust machine.

5. Characteristics of Computers

Computers possess a number of characteristics which have been discussed below:

Speed

The speed of modern computers is amazing. Today, the computers are able to calculate even in pico seconds ($10^{-}12$ second). A Computer can do more than 3 lac calculations like addition, subtraction etc. in only one second. Its internal speed is virtually instantaneous. This characteristic of computers is very important and useful for human because forecasting is easy. Computers can forecast weather in advance and thus the information of the weather can be given well in advance to the people living at sea-shores or in hilly areas.

Accuracy

The accuracy of the computers is consistently very high. The work performed by the computers is error-free and if there is any error, it is due to its wrong use. Mostly the errors are made by the user himself and not by the machine. If the programming is correct and the data feeded into the computer is accurate, then the results furnished by the computers are always accurate. Computers are capable of performing almost any job without any sign of tiredness.

Storage

Computer has the capability to store data on a large scale in its memory. A large quantity of data/information can be stored in it and can be recalled in no time in case of need. A computer has two types of memory. One is called permanent and another is temporary. Data or information can be stored temporarily in the Main Memory. This memory is limited. On the other hand the secondary memory is large and the data can be stored permanently. This memory is also termed as Auxiliary Memory. The capacity of memory is measured in terms of bytes. The higher units are Kilobytes, Megabytes and Gigabytes. For storage of data, devices like magnetic tapes, floppies, disks etc. are used.

Communications

Today computer is mostly used to exchage messages or data through computer networks all over the world. The information can be received or send through the internet with the help of computer. It is the most important feature of modern IT.

Consistency

People often have difficulty to repeat their instructions again and again e.g. a lecturer feels difficult to repeat the same lecture in a class room again and again. Computer can repeat actions consistently without loosing its concentration.

Versatility

A Computer is capable of performing logical operations. For logical operations it makes use of its internal control (CPU). It can perform the job given to it without any break for a very long duration. It is capable of doing the following functions:

- It transfers the data internally.
- It can perform the functions of comparison.
- It performs arithmetical operation.
- It exchanges information with the outside world.

Automation

Automation is one of the most important characteristics of the computer. Once the command is given to the computer, it can perform the job without the need of human intervention until the completion of the job. If something is to be printed in output form and the necessary instructions are given to the computer, it transfers the data continuously to the printer until the completion of work. The automation of computers is of utmost importance in Industries.

Diligence

Computer does not suffer from the human traits of tiredness. It is capable of performing the job with full concentration. It can be put to work continuously for several hours and it will perform the job with same speed and accuracy.

Due to these characteristics, the computers are being used in designing, science, engineering, hospitals, schools and universities etc.

6. Limitations of Computers

Computers are very good at what they do, but there are many tasks that they can't do. They can't do anything unless they are first programmed with specific instructions. Computer can't decide how they are to be programmed or provide their own input; they can't interpret the data they generate; they can't implement any decisions that they suggest; and they can't "THINK". For example they can be programmed to store recipes, but they can't decide to fix dinner. They can keep track of scientific data, but they can't conceive of express the ideas for continued research. Their memories can contain the contents of encyclopedias, but only humans can decide what to do with that knowledge.

7. Computer System

A computer system consists of a computer and supporting devices for input, output and storage of data. The data to be processed is supplied to the computer with the help of input

devices. The processing unit performs the desired operations on the information and the results of calculations/processing are obtained on the output devices. Several types of input/output devices can be attached to the computer. A computer consists of electronic circuits only, while the input/output devices have both electronic and mechanical components. The basic organization of any computer is shown in figure:

Computer system

The input device supplies the data to the computer. Most commonly used input devices are: Keyboard, Magnetic tape, Floppy disk drive, Hard disk drive, Mouse, MICR and Scanners etc. We specify the data in a form which we use in our everyday life, that is in the numeric and alphabetic form. These are converted into the form which computer can 'understand' i.e. binary form. After the computer has processed the data, results are obtained on the output devices. Commonly used devices are printers and plotters. The results obtained are in the human readable form.

Normally when we say computer - that means a complete computer system.

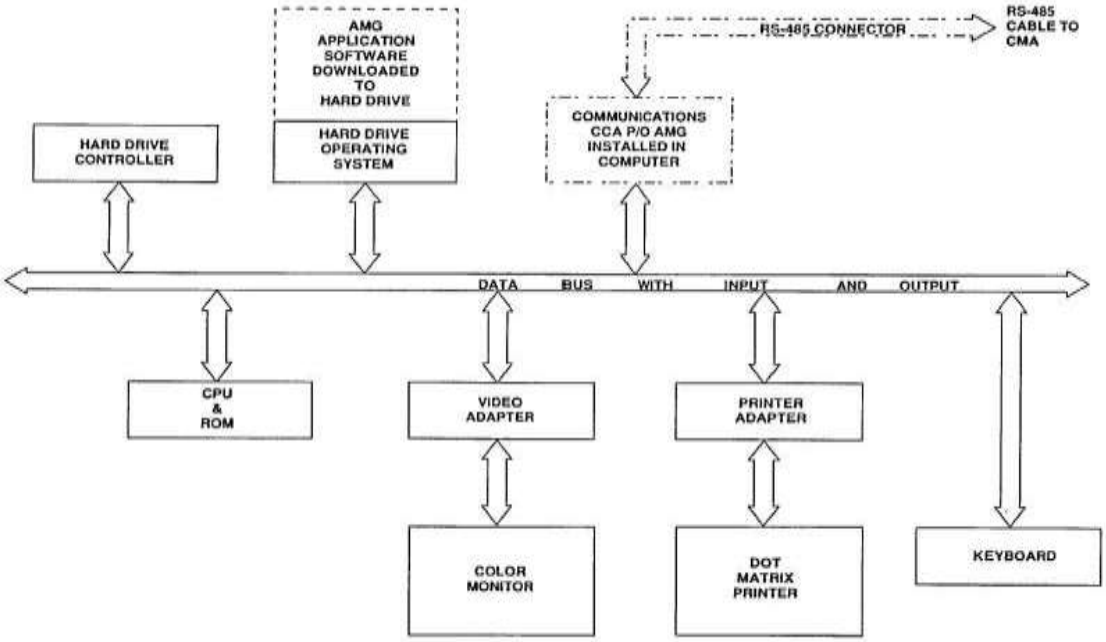
7.1 Central Processing Unit (C.P.U.)

The computer does all the computing and data processing work in Central Processing Unit (C.P.U.). Its main components are:

a) Arithmetic and Logical Unit (ALU)
b) Control Unit (CU)
c) Main Memory Unit (MMU)

For processing of data Information is transferred to and fro from one unit to other as shown below.

7.2 Block diagram of Computer:



7.3 Arithmetic and Logical Unit:

This unit consists of complicated electronic circuits designed using the concepts of Boolean algebra. All arithmetic operations-addition, subtraction, multiplication, division and logical operations-comparison, decision etc. are performed by this unit.

7.4 Control Unit:

The control unit also consists of electronic circuits. It acts as a supervisor in a computer system. It obtains instructions from the main memory, interprets them, decides the action to be taken and directs other units to execute them. It keeps check on correct information flow in the computer system. Normally, the instructions are executed sequentially (one after another) in the machine. The control unit also provides the facility to alter this sequence.

7.5 Main Memory Unit:

This unit stores all the data which are to be processed and the program instructions for carrying out the processing/computing work. The main memory is also referred to as Primary or Main storage. It is extremely fast (High speed memory) and generally consists of magnetic cores (older systems) or semi-conductor/microprocessors (modern systems). Information can be entered/retrieved at random from the main memory.

The ALU, MMU and the CU are also referred to as Central Processing Unit (CPU).

Hardware:

Hardware refers to objects that we can actually touch, like disks, disk drives, display screens, keyboards, printers, boards and chips etc.

Software:

Software is a set of instructions. It is untouchable. Software exists as ideas, concepts, and symbols, but it has no substance. The distinction between software and hardware is sometimes confusing because they are so integrally linked. Clearly, when you purchase a program, you are buying software. But to buy the software, you need to buy the disk (hardware) on which the software is recorded.

Books provide a useful analogy. The pages and the ink are the hardware, while the words, sentences, paragraphs and the overall meaning are the software. A computer without software is like a book full of blank pages -- you need software to make the computer useful just as you need words to make a book meaningful.

Similarly TV is hardware. Programs being relayed are software. If no program is being relayed then TV is nothing but a waste box. Similarly without software computer is nothing but a waste box.

Types of Software:

System software:

It includes the operating system and all the utilities that enable the computer to function.

Application software: An application program (sometimes shortened to application) is any program designed to perform a specific function directly for the user or, in some cases, for another application program. It includes programs that do real work for users. Examples of application programs include word processors, spreadsheets, database management systems; Web browsers; development tools; drawing, paint and image editing programs; and communication programs. Application programs use the services of the computer's operating system and other supporting programs. The formal requests for services and means of communicating with other programs that a programmer uses in writing an application program is called the application program interface (API).

Bit: Computer stores a variety of data and information in its memory, including numbers (0-9), letters (A-Z), symbols and other characters (#,{},',~,^). A computer uses the *binary system* to represent these characters. In a binary system, only two digits, 0 and 1, are used. The 0's and 1's in the binary system are known as bits. A bit is a binary digit, taking a value of either 0 or 1. Binary digits are a basic unit of information storage and communication in digital computing and digital information theory.

Byte: A byte (pronounced "bite") is the basic unit of measurement of information storage in computer science. In many computer architectures it is a unit of memory addressing, most often consisting of eight bits. A byte is one of the basic integral data types in some programming languages, especially system programming languages.

A byte is an ordered collection of bits, with each bit denoting a single binary value of 1 or 0. The size of a byte can vary and is generally determined by the underlying computer operating system or hardware, although the 8-bit byte is the standard in most of the systems. Historically, byte size was determined by the number of bits required to represent a single character from a Western character set. Its size was generally determined by the number of possible characters in the supported character set and was

chosen to be a divisor of the computer's word size. Historically bytes have ranged from five to twelve bits.

Since computer memory comes in a power of two rather than 10, a large portion of the software and computer industry use binary estimates of the quantities, Kilobytes, Megabytes, Gigabytes and Terabytes are higher units for measuring the capacity of memory or storage devices. To understand the relationship between them, please refer the following table.

8bits	2^0 * 8 bits	=	1 byte	=	1 byte
2^{10} bytes	2^{10}*8 bits	=	1134 bytes	=	1 Kilobyte (KB)
2^{10} KB	2^{20}*8 bits	=	1134 KB	=	1 Megabyte (MB)
2^{10} MB	2^{30}*8 bits	=	1134 MB	=	1 Gigabyte (GB)
2^{10} GB	2^{40} * 8 bits	=	1134 GB	=	1 Terabyte (TB)

9. Summary

Computer can be described as an information-processing machine which can perform arithmetic operations (Addition, Subtraction, Multiplication and Division etc.) and which can take logical decisions. Main characteristics of computer are speed, accuracy, storage, versatility, automation and diligence. The speed of modern computers is amazing. Today, the computers are able to calculate even in pico seconds ($10^{-}12$ second). A Computer can do more than 3 lac calculations like addition, subtraction etc. in only one second. Its internal speed is virtually instantaneous. The accuracy of the computers is consistently very high. The work performed by the computers is error-free and if there is any error, it is due to its wrong use. Mostly the errors are made by the user himself and not by the machine. Computer has the capability to store data on a large scale in its memory. A large quantity of data/information can be stored in it and can be recalled in no time in case of need. A computer has two types of memory. One is called permanent and another is temporary. Automation is one of the most important characteristics of the computer. Once the command is given to the computer, it can perform the job without the need of human intervention until the completion of the job. Computer can be used for vast variety of applications. Computer does not suffer from the human traits of tiredness. It is capable of performing the job with full concentration. It can be put to work continuously for several hours and it will perform the job with same speed and accuracy. Due to these characteristics, the computers are being used in designing, science, engineering, hospitals, schools and universities etc. Computer system consists of a computer and supporting devices for input, output and storage of data. Several types of input/output devices can be attached to the computer. The computer does all the computing and data processing work in Central Processing Unit (C.P.U.). Main components of CPU are Arithmetic and Logical Unit (ALU); Control Unit (CU) and Main Memory Unit (MMU). All arithmetic operations-addition, subtraction, multiplication, division and logical operations-comparison, decision etc. are performed by the ALU unit. Control unit acts as a supervisor in a computer

system. It obtains instructions from the main memory, interprets them, decides the action to be taken and directs other units to execute them. Main memory unit stores all the data which are to be processed and the program instructions for carrying out the processing/computing work. The main memory is also referred to as Primary or Main storage. It is extremely fast (High speed memory) and generally consists of magnetic cores (older systems) or semi-conductor/microprocessors (modern systems). Information can be entered/retrieved at random from the main memory.

10. Keywords

Computer	Computer is an information-processing machine, which can perform arithmetic operations (Addition, Subtraction, Multiplication and Division etc.) and which can take logical decisions having memory and capability to store information and instructions.
Computer System	Computer system consists of a computer and supporting devices for input, output and storage of data.
ALU	Arithmetic and Logical Unit
CU	Control Unit
MMU	Main Memory Unit
CPU	Central Processing Unit
Hardware	Hardware refers to objects that we can actually touch, like disks, disk drives, display screens, keyboards, printers, boards and chips etc.
Software	Software is a set of instructions. It is untouchable. Software exists as ideas, concepts and symbols, but it has no substance.
Bit	A bit is a binary digit, taking a value of either 0 or 1. Binary digits are a basic unit of information storage and memory.
Byte	A byte is an ordered collection of bits, with each bit denoting a single binary value of 1 or 0.

11. Short answer type Questions

1. Explain the function of CPU, ALU,CU and MMU
2. Describe the role of computer in our daily life?
3. Differentiate between Hardware and Software.
4. Differentiate between Bit and Byte.
5. Write the full form of the following abbreviations
    a) CPU
    b) ALU
    c) CU
    d) MMU

12. Long answer type Questions

1. Draw a block diagram of computer system and explain the function of various units.
2. Discuss the various characteristics of computers.
3. Describe various benefits of computers.

13. Suggested Readings

- Information Technology by Satish Jain
- Information Technology and Management by Turban Mclean and Wetbrete
- Computer Fundamentals by Pradeep Kumar Sinha and Priti Sinha
- Fundamentals of Computer by V.Rajaraman, PHI, India.

LESSON NO. 4 **AUTHOR: JAGMOHAN SINGH JUNEJA**
CONVERTED INTO SLM BY: DR. VISHAL SINGH

INPUT DEVICES

1. Objectives

Objectives of this lesson are to familiarize with the various input devices, which are being used to communicate with the computer.

2. Introduction

As already explained that to communicate with the computer, we need input and output devices. For computer processing, data needs to be entered into the computer through input

devices and the result of processing needs to be communicated to the user through output devices. Several input and output devices have been developed so far. With the passage of time and with the advent of new technologies new advanced and more efficient input and output devices have been developed. As a result of this some of the input output devices have become obsolete. Input/Output devices form an integral part of a computer system. Without them, a computer is hardly of any use. The Input/Output devices are also referred to as the Peripheral Devices. Following are some of the commonly used input devices which are developed so far.

3. Input Devices

1. Punched Paper Tape	**2. Punched Cards**
3. Magnetic Tape	**4. Magnetic Drum**
5. Keyboard	**6. Mouse**
7. Floppy Diskette	**8. Hard Disk Drive**
9A. Track ball	**10. Touch Screen**
11. Joy Stick	**12. Digitizer Tablet/ Pen tablet**
13. Light Pen	**14. Scanner**
15. MICR	**16. Microphone**

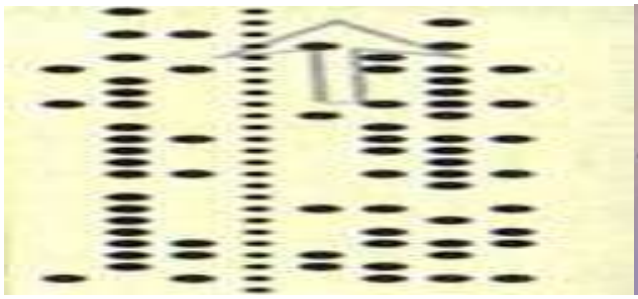
17. Vision System (Digital/ Video cameras)

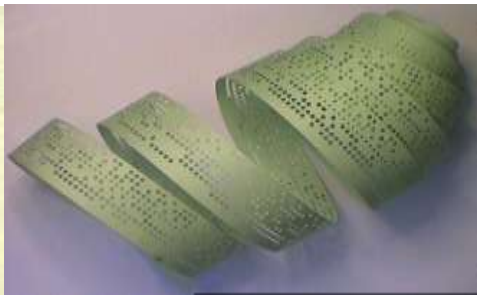
18 CD-ROM/DVD

Study of all these devices in details is very lengthy. Moreover some of these devices have become obsolete. Therefore we will not discuss them in detail.

3.1 Punched Paper tape

Punched tape or paper tape consisting of a long strip of paper in which holes are punched to store data. It was widely used during much of the twentieth century for tele printer





communication, and later for input, output and for storage medium for minicomputers. Now-a-days these have become obsolete.

3.2 Punched Card

A punch card or punched card (or punchcard or Hollerith card or IBM card), is a piece of stiff paper that contains digital information represented by the presence or absence of holes in

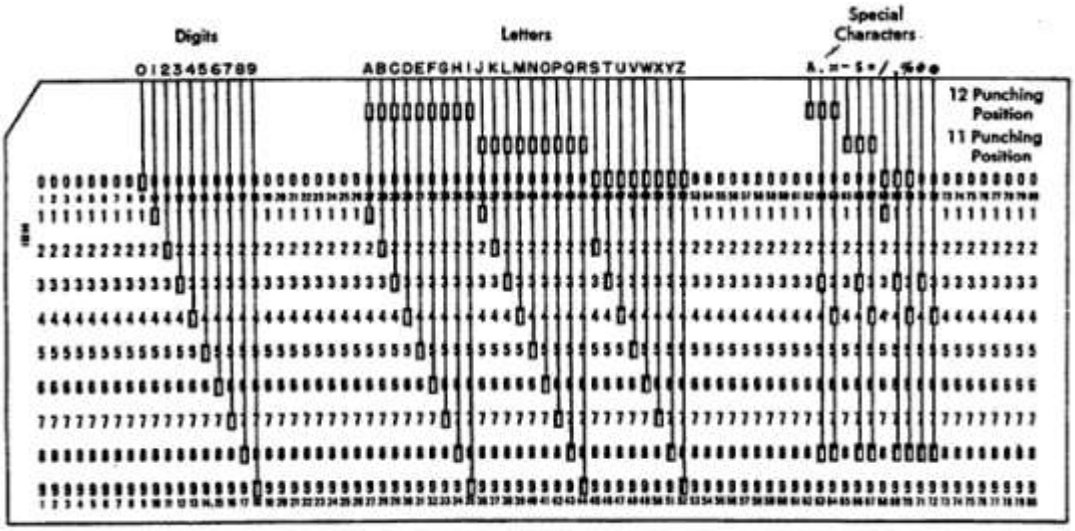


Figure 2. Punching Positions in Card

predefined positions. Punched cards were widely used throughout the 19th century for controlling textile looms and in the late 19th and early 20th century for operating fairground organs and related instruments. Early digital computers used punched cards as the primary medium for input of both computer programs and data, with offline data entry on key punch machines. Some voting and sorter machines also used punched cards.

Now-a-days these have become obsolete

3.3/3.4 Magnetic Tape/Magnetic Drum - These have been discussed in the next Unit.

3.5 Keyboard:

Keyboard is an input device partially modeled after the typewriter keyboard which uses an arrangement of buttons or keys which act as electronic switches. A keyboard typically has characters engraved or printed on the keys and each press of a key typically corresponds to a single written symbol. However, to produce some symbols requires pressing and holding several keys simultaneously or in sequence. While most keyboard keys produce letters, numbers or signs (characters), other keys or simultaneous key presses can produce actions or computer commands.

On most computers, a keyboard is the primary text input device. (The mouse is also a primary input device but lacks the ability to easily transmit textual information.) The keys on computer keyboards are often classified as follows:

- **Alphanumeric keys** -- letters and numbers
- **Punctuation keys** -- comma, period, semicolon and so on.
- **Special keys** -- function keys, control keys, arrow keys, Caps Lock key, Escape key, tab, cursor movement keys, shift keys, sometimes other manufacturer-customized keys and so on.

KeyBoard

The computer keyboard uses the same key arrangement as the mechanical and electronic typewriter keyboards that preceded the computer. Because many keyboard users develop a cumulative trauma disorder, such as carpal tunnel syndrome, a number of ergonomic keyboards have been developed. Approaches include keyboards contoured to alleviate stress and foot-driven pedals for certain keys or keyboard functions

Standard keyboards such as the 104-key Windows keyboards include alphabetic characters, punctuation symbols, numbers and a variety of function keys. Keyboards with extra keys such as multimedia keyboards have special keys for accessing music, web and other often-used programs, a mute button, volume buttons or knob and standby (sleep) button. Similarly gaming keyboards have extra function keys which can be programmed with keystroke macros. For example, ctrl+shift+y could be a keystroke that is frequently used in a certain computer game. Shortcuts marked on color-coded keys are used for some software applications and for specialized for uses including word processing, video editing, graphic design and audio editing etc.

Maintenance of the Keyboard

1. Excessive pressure and dirt on the keys can damage the internal circuit as they are very sensitive.
2. Clean your keyboard regularly.
3. Do not eat or drink while using keyboard.

3.6 Mouse

It is a small device that controls the movement of the cursor or pointer on a display screen. It can be rolled along a hard, flat surface, in order to point to a place on a display screen and to select one or more actions to take from that position. Its name is derived from the real mouse as its shape, which looks a bit like a mouse and the mouse pointer can be moved very quickly on the display screen just like as the real mouse moves very fast. As you move the mouse, the pointer on the display screen moves in the same direction. It contains at least one button and sometimes as many as three, which have different functions depending on what program is running.

The most conventional kind of mouse has two buttons on top: the left one is used most frequently. In the Windows operating systems, it lets the user click once to send a "Select" indication that provides the user with feedback that a particular position has been selected for further action. The next click on a selected position or two quick clicks on it causes a particular action to take place on the selected object. For example, in Windows operating systems, it causes a program associated with that object to be started. The second button, on the right, usually provides some less-frequently needed capabilities. For example, when viewing a Web page, you can click on an image to get a popup menu that, among other things, lets you save the image on your hard disk. Some mouses have a third button for additional capabilities. Some mouse manufacturers also provide a version for left-handed people else left and right mouse buttons can also be interchanged through software.

There are three basic types of mouse:

1. **Mechanical:** It consists of a metal or plastic housing or casing, a rubber or metal ball that sticks out of the bottom of the casing and can be rolled on a flat surface in all directions, one or more buttons on the top of the casing. As the ball is moved over the surface in any direction, a sensor sends impulses to the computer that causes a mouse-responsive program to reposition a visible indicator (called a cursor) on the display screen. The positioning is relative to some variable starting place. Viewing the cursor's present position, the user readjusts the position by moving the mouse.
2. **Opto-mechanical:** Same as a mechanical mouse, but uses optical sensors to detect motion of the ball.
3. **Optical:** Uses a laser to detect the mouse's movement. Optical mechanism has a frame of reference. Optical mice have no mechanical moving parts. They respond more quickly and precisely than mechanical and opto-mechanical mice, but they are also expensive.

Windows 95 or higher versions and other operating systems let the user adjust the sensitivity of the mouse, including how fast it moves across the screen, and the amount of time that must elapse within a "double click.". In some systems, the user can also choose among several different cursor appearances. Some people use a mouse-pad to improve traction for the mouse ball.

Although the mouse has become a familiar part of the personal computer, its design continues to evolve and there continue to be other approaches to pointing or positioning on a

display. Notebook computers include built-in mouse devices that let you control the cursor by rolling your finger over a built-in trackball. IBM's Scroll Point mouse adds a small "stick" between two mouse buttons that lets you scroll a Web page or other content up or down and


Mouse

right or left. Users of graphic design and CAD applications can use a stylus and a specially-sensitive pad to draw as well as move the cursor. Other display screen-positioning ideas include a video camera that tracks the user's eye movement and places the cursor accordingly. Mouse can be connected to Serial, PS/2 and USB port. For different ports different mouse are available.

Cordless mouse are not physically connected at all. Instead they rely on infrared or radio waves to communicate with the computer. Cordless mice are more expensive than both serial and bus mice, but they do eliminate the cord, which can sometimes get in the way.

Maintenance of Mouse

1. Always use a mouse pad.
2. If there is no mouse pad then place the mouse on a clean flat surface.
3. Do not stretch the mouse cable.
4. Do not expose the mouse to excessive moisture.
5. Regularly clean your mouse to work it properly.

3.7/3.8 Floppy Diskettes/ Hard Disk Drives – These are discussed in the next Unit under the heading Storage devices

3.9 Trackball

A trackball is a pointing device consisting of a ball housed in a socket containing sensors to detect rotation of the ball about two axes—like an upside-down mouse with an exposed protruding ball. The user rolls the ball with the thumb, fingers or the palm of the hand to move a cursor. Normally these are used in portable computers/laptops, where there may be no desk space on which to run a mouse.

3.10 Touch Screen

A display screen that is sensitive to the touch of a finger or stylus. It allows a user to interact with the computer by touching pictures or words on the screen. Widely used on ATM

machines, retail point-of-sale terminals, car navigation systems, medical monitors and

industrial control panels , the touch screen offers several advantages. It is resistant to harsh environments and on-screen buttons created by software enable an infinite number of options to be presented to the user without requiring a keyboard. They also accept hand printing, handwriting and graphics.

All touch screens "digitize" the point of contact on screen into an X-Y coordinate. Although touch screens provide a natural interface for computer novices, they are unsatisfactory for some applications because the finger is such a relatively large object. It is impossible to point accurately to small areas of the screen.

3.11 Joystick

A lever that moves in all directions and controls the movement of a pointer or some other display symbol. A joystick is similar to a mouse, except that with a mouse the cursor stops moving as soon as you stop moving the mouse. With a joystick, the pointer continues moving in the direction the joystick is pointing. To stop the pointer, you must return the joystick to its upright position. Most joysticks include two buttons called triggers. Joysticks are used mostly for computer games, but they are also used occasionally for CAD/CAM systems and other applications.

3.12 Digitizer Tablet

A digitizer tablet (or digitizing tablet, graphics tablet, graphics pad, drawing tablet) is a computer input device that allows one to hand-draw images and graphics, similar to the way one draws images with a pencil and paper. These tablets may also be used to capture data of handwritten signatures. It is used for sketching new images or tracing old ones. The user contacts the surface of the device with a wired or wireless pen or puck. Often mistakenly called a mouse, the puck is officially the "tablet cursor." A graphics tablet (also called pen pad) consists of a flat surface upon which the user may "draw" an image using an attached stylus, a pen-like drawing apparatus. The image generally does not appear on the tablet itself but, rather, is displayed on the computer monitor. Some

tablets however, come as a functioning secondary computer screen that you can interact with directly using the stylus.

Some tablets are intended as a general replacement for a mouse as the primary pointing and navigation device for desktop computers.

For sketching, either the pen or puck is used. For tracing, the puck is preferred because its crosshairs, visible through a clear glass lens, lets you precisely pinpoint ends and corners of detailed drawings. Most tablets allow parts of the tablet surface to be customized into buttons that can be tapped to select menus and functions in the application.

Pen tablet

A digitizer tablet that is specialized for handwriting and hand marking. LCD-based tablets emulate the flow of ink as the tip touches the surface and pressure is applied. Non-display tablets display the handwriting on a separate computer screen.

3.13 Light Pen

An input device that utilizes a light-sensitive detector to select objects on a display screen. It is a light-sensitive stylus wired to a video terminal used to draw pictures or select menu options. The user brings the pen to the desired point on screen and

presses the pen button to make contact. Contrary to what it looks like, the pen does not shine light onto the screen; rather, the screen beams into the pen. Screen pixels are constantly being refreshed. When the user presses the button, the pen senses light and the pixel being illuminated at that instant identifies the screen location.

3.14 Scanner

A scanner is a device that optically scans images, printed text, handwritten documents and other objects directly and converts them to digital images. After scanning the text documents, with the help of application softwares (OCR/ICR) data can be converted to editable text format. OCR (Optical Character Recognition) software can convert typed text and numbers into machine readable strings and documents. OCR software can recognize a wide variety of fonts in different languages but handwriting and script fonts that mimic handwriting are still problematic. ICR (Intelligent Character Recognition) can convert handwritten text and numbers into machine readable strings and documents. For example, an application using ICR technology can convert handwritten reports into PDF files or Word Doc files.

Types of Scanners

Flatbed Scanner

The Flatbed scanner is one of the most commonly used and most recommended scanners. This scanner allows the user to place a full piece of paper, book, magazine, photo or any other object onto the bed of the scanner and have the capability to scan

that object. While the Flatbed scanner is an excellent recommendation, expect more desk space to be used than any other option as well expect to pay more for the scanner.

Sheet fed Scanners

Another commonly used scanner which allows a user to scan pieces of paper into the computer. While the sheetfed is a less expensive solution when compared to the flatbed scanner, normally sheetfed scanners have limited resolution upto 400dpi. These scanners are more like a fax machine than a copier, because they move the page being scanned past the scanning head, rather than the other way around. Sheetfed scanner is a good choice for handling paperwork without giving up much desk space.

Drum Scanners

Before the advent of desktop scanning, most images were loaded into computers through drum scanners. Expensive and difficult to operate, these units were found primarily in color prepress companies. Technicians there would carefully mount originals on a glass cylinder, which would then be rotated at high speeds around a sensor located in the center.

Handheld Scanners

Today, not commonly used scanner option and can be difficult to find at stores. The handheld option allows the user to drag over select sections of pages, magazines, books and other objects. While it is a very inexpensive solution, it can be

tedious to drag the handheld correctly. While scanning, it will be difficult to have a straight scan as well as if it is moved to slow / fast can cause distortion in the image being scanned. It is difficult to obtain a high-quality image with it.

Cardscan scanners

Excellent solution for anyone interested in scanning business cards for record purposes.

OMR Scanners

Optical Mark Reader (OMR scanner) is a high-tech data input device. OMR (Optical Mark Recognition) is used for recognizing optical marks. Typical applications of OMR scanners are the processing of questionnaires, ballots, educational tests and reporting, ordering sheets, data statistics and evaluation in fields such as vote, transportation, human resources, fiscal taxation and finance etc., where the documents to be processed are form-like and filled in by hand by the respondents.

Bar Code scanners

A barcode reader, also called a price scanner or point-of-sale (POS) scanner, is a hand-held or stationary input device used to capture and read information contained in a bar code . A barcode reader consists of a scanner , a decoder (either built-in or external), and a cable used to connect the reader with a computer. Because a barcode reader merely captures and translates the barcode into numbers and/or letters, the data must be sent to a computer so that a software application can make sense of the data. A barcode reader works by directing a beam of light across the bar code and measuring the amount of light that is reflected back. (The dark bars on a barcode reflect less light than the white spaces between them.) The scanner converts the light energy into electrical energy, which is then converted into data by the decoder and forwarded to a computer.

Modern scanners typically use a charge-coupled device (CCD) or a Contact Image Sensor (CIS) as the image sensor, whereas older drum scanners use a photomultiplier tube as the image sensor. A rotary scanner, used for high-speed document scanning, is another type of drum scanner, using a CCD array instead of a photomultiplier. Other types of scanners are planetary scanners, which take photographs of books and documents and 3D scanners, for producing three-dimensional models of objects. 3D scanners used for industrial design, reverse engineering, test and measurement, gaming and other applications. Mechanically

driven scanners that move the document are typically used for large-format documents, where a flatbed design would be impractical.

Scanners can be connected to the computer through Parallel, SCSI and USB ports. SCSI port scanners can transfer the data at a much faster speed than the parallel port scanners. USB is becoming a very popular interface for scanners as it generally allows the user to connect the scanner and be ready to scan in a matter of minutes.

3.15 MICR

Magnetic Ink Character Recognition or MICR (pronounced my-ker or micker), a character recognition technology adopted mainly by the banking industry to facilitate the processing of cheques. Magnetic Ink Character Recognition is a character recognition system that uses special ink and characters. When a document that contains this ink needs to be read, it passes through a machine, which magnetizes the ink and then translates the magnetic information into characters. Numbers and characters found on the bottom of cheques (usually

containing the cheque number, sort number, and account number) are printed using Magnetic Ink. MICR provides a secure, high-speed method of scanning and processing information. In addition to their unique fonts, MICR characters are printed with a magnetic ink, usually containing iron oxide. Magnetic printing is used so that the characters can be reliably read into a system, even when they have been overprinted with other marks such as cancellation stamps or signatures etc. The MICR typeface has only 14 characters in it: the numbers 0-9 and special symbols.

3.16 Microphone

Input to a computer can also be given through voice via microphone. Microphone is a device for converting sound waves into electrical energy or to convert sound waves or signals

into electric signals. Most of the computers now have a built-in microphone to record speech and sounds into the computer.

3.17 Vision System (Webcam/Digital/ Video camera)

Input to a computer can also be given through Web, Digital or Video camera.

Webcam (Web Camera)

Webcam is small camera, which is attached to someones computer. Normally it is used for accessing images either continuously or at regular intervals using World Wide Web, instant messaging, or a PC video conferencing application. Normally it is a low-resolution digital video camera. Webcam software typically captures the images as JPEG or MPEG format. There are countless Webcam sites on the Internet that have cameras pointed at virtually everything. Some Webcams are set up in people's houses and allow you to watch them as they go about their day to day business.

Digital camera

It is a camera that captures images electronically rather than on film. The image is captured by an array of charge-coupled devices (CCDs), stored in the camera's random access memory or a special diskette, and transferred to a computer for modification, long-term storage, or printing out. Since the technology produces a graphics file, the image can be readily edited using suitable software. Models designed and priced for the mass consumer market—as opposed to costly models designed for photojournalism and industrial photography. They appeal particularly to users who want to send pictures over the Internet or to crop, combine, enhance, or otherwise modify their photographs.

It records images in digital form, unlike traditional film cameras that record a light image on film (analog), digital cameras record discrete numbers for storage on a flash memory card or optical disc. As with all digital devices, there is a fixed, maximum resolution and number of

colors that can be represented. Images are transferred to the computer with a USB cable, a memory card or wireless. Modern compact digital cameras are typically multifunctional, with some devices capable of recording sound and/or video as well as photographs with zoom ability. Many Live-Preview Digital cameras have a "movie" mode, in which images are continuously acquired at a frame rate sufficient for video.

Resolution in Megapixels

The number of pixels determines the maximum size of the resulting image and its sharpness, especially when printed. The higher the resolution to start, the better the results. You can easily reduce a high-resolution image to low resolution in the computer, but you cannot go from low to high with great results.

Professional video cameras such as those used in television and movie production. These typically have multiple image sensors (one per color) to enhance resolution and color gamut. Professional video cameras usually do not have a built-in VCR or microphone.

Camcorders used by amateurs. They generally include a microphone to record sound, and feature a small liquid crystal display to watch the video during taping and playback.

Video camera

A camera that takes continuous pictures and generates a signal for display or recording.

These types of cameras are suitable for movies. A camera which contains an electronic image sensor and records on Tape, CD, Memory card or on Hard disk rather than photographic film. These types of Camera are capable of acquiring and delivering full-motion video. Converts the moving image into a series of horizontal lines, A camera that captures light on chips that convert light into electronic impulses (CCDs) and then fix the electronic impulses onto tape etc Now-a-days portable hand-held video cameras that records onto videocassettes for playback on a television set are available at affordable prices.

CD-ROM/DVD - These are discussed in the next Unit under the heading Storage devices

Summary

To communicate with the computer, we need input and output devices. For computer processing, data needs to be entered into the computer through input devices and the result of processing needs to be communicated to the user through output devices. Several input and output devices have been developed so far. With the passage of time and with the advent of new technologies new advanced and more efficient input and output devices have been developed. Different Input Devices are Punched Paper Tape, Punched Cards, Magnetic Tape, Magnetic Drum, Keyboard, Mouse, Floppy Diskette, Hard Disk Drive, Track ball, Touch Screen, Joy Stick, Digitizer Tablet/ Pen tablet, Light Pen, Scanner, MICR, Microphone, Vision System (Digital/ Video cameras) and CD-ROM/DVD. **Punched Paper tape** is a paper tape of consisting of a long strip of paper in which holes are punched to store data. **Punched card** is a piece of stiff paper that contains digital information represented by the presence or absence of

holes in predefined positions. **Keyboard** is the primary text input device. The computer keyboard uses the same key arrangement as the mechanical and electronic typewriter keyboards that preceded the computer. **Mouse** is a small device that controls the movement of the cursor or pointer on a display screen. It can be rolled along a hard, flat surface, in order to point to a place on a display screen and to select one or more actions to take from that position. **Trackball** is a pointing device consisting of a ball housed in a socket containing sensors to detect rotation of the ball about two axes—like an upside-down mouse. **Touch Screen** is a display screen that is sensitive to the touch of a finger or stylus. It allows a user to interact with the computer by touching pictures or words on the screen. **Joystick** is a lever that moves in all directions and controls the movement of a pointer or some other display symbol. A joystick is similar to a mouse, except that with a mouse the cursor stops moving as soon as you stop moving the mouse. With a joystick, the pointer continues moving in the direction the joystick is pointing. **Digitizer Tablet** is a computer input device that allows one to hand-draw images and graphics, similar to the way one draws images with a pencil and paper. **Light Pen** is an input device that utilizes a light-sensitive detector to select objects on a display screen. **Scanner** is a device that optically scans images, printed text, handwritten documents and other objects directly and converts them to digital images. After scanning the text documents, with the help of application softwares (OCR/ICR) data can be converted to editable text format. Different type of available scanners are Flatbed Scanners, Sheet fed Scanners, Drum Scanners, Handheld Scanners, Cardscan scanners, OMR Scanners and Bar Code scanners. **MICR -** Magnetic Ink Character Recognition is a character recognition technology adopted mainly by the banking industry to facilitate the processing of cheques. Magnetic Ink Character Recognition is a character recognition system that uses special ink and characters. Microphone is a device for converting sound waves into electrical energy or to convert sound waves or signals into electric signals. **Webcam (Web Camera)** Webcam is small camera, which is attached to someone's computer to capture the images. **Digital camera** is a camera that captures images electronically rather than on film.

Keywords

Keywords of this lesson are "**Input devices, Punched Paper Tape, Punched Cards, Magnetic Tape, Magnetic Drum, Keyboard, Mouse, Floppy Diskette, Hard Disk Drive, Track ball, Touch Screen, Joy Stick, Digitizer Tablet/ Pen tablet, Light Pen, Scanners, Webcam, Digital camera, Video camera, MICR, Microphone and CD-ROM/DVD".** These have been explained briefly in the summary.

Short answer type Questions

1. Name the different Input devices.
2. Write short notes on the any of three following input devices.
    - Punched Paper Tape
    - Punched Cards
    - Keyboard
    - Mouse

- Track ball
- Touch Screen
- Joy Stick
- Digitizer Tablet/ Pen tablet
- Light Pen
- Scanner

Long answer type Questions

1. What are the different Input devices? Explain the function of each.
2. Describe the different types of keyboards.
3. What is the use of scanner? What types of scanners are available?

Suggested Readings

1. Information Technology by Satish Jain
2. Information Technology and Management by Turban Mclean and Wetbrete
3. Computer Fundamentals by Pradeep Kumar Sinha and Priti Sinha
4. Fundamentals of Computer by V.Rajaraman, PHI, India.

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OUTPUT DEVICES

1. Objectives

Objectives of this lesson are to familiarize with the different output devices, which are being used to communicate with the computer.

2. Introduction

As already explained that to communicate with the computer, we need input and output devices. For computer processing, data needs to be entered into the computer through input devices and the result of processing needs to be communicated to the user through output devices. Several input and output devices have been developed so far. With the passage of time and with the advent of new technologies new advanced and more efficient input and output devices have been developed. Following are some of the commonly used output devices which are developed so far.

3. OUTPUT DEVICES

- **Punched Tape**
- **Punched Cards**
- **Magnetic Tape**
- **Magnetic Drum**
- **Visual Display Units (Monitors)**
- **Floppy Diskette**
- **Hard Disk Drive**
- **Printers**
- **Plotters**
- **Voice Response System**
- **CD - RW/DVD-RW**

3.1 Punched Paper tape – Already explained in the previous lesson.

3.2 Punched Card– Already explained in the previous lesson.

3.3/3.4 Magnetic Tape/Magnetic Drum - These have been discussed in the next Unit.

3.5 Visual Display Units (Monitors)

A **computer display monitor**, usually called simply a **Monitor or Terminal or VDU (Video display unit)**, is a piece of electrical equipment which displays viewable images generated by a computer. It is a display screen used to present output from a computer. A computer display device is usually either a cathode ray tube (CRT) or some form of flat panel such as a TFT LCD display. The clarity of a monitor is based on video bandwidth, dot pitch, refresh rate and convergence. The monitor comprises the display device, circuitry to generate a picture from electronicsignals sent by the computer. Within the computer, either as an integral part or a plugged-in interface, there is circuitry to convert internal data to a format compatible with a monitor.


CRT Monitor

TFT (Thin Film Transistor) monitor uses thin-film transistor technology. It is a type of LCD (liquid crystal display) flat-panel display technology. Normally these are called flat panel displays. Compared to other types of LCD technology, TFT features excellent image quality and response time, but more expensive. TFT technology is an active-matrix technology, meaning that a tiny circuit (a transistor) is located next to each pixel, allowing the pixel to be turned on and off individually. This permits faster response time and greater contrast compared to passive-matrix technology. Now-a-days TFT has replaced old style cathode ray t

ubes (CRTs). Nearly all LCD monitors today use TFT technology. A typical 17-inch TFT monitor has about 1.3 million pixels and 1.3 million transistors.

There are many ways to classify monitors. The most basic is in terms of color capabilities, which separates monitors into three classes:

Monochrome : Monochrome monitors actually display two colors, one for the background and one for the foreground. The colors can be black and white, green and black or amber and black.

Gray-scale : A gray-scale monitor is a special type of monochrome monitor capable of displaying different shades of gray.

Color: Color monitors can display anywhere from 16 to over 1 million different colors. Color monitors are sometimes called RGB monitors because they accept three separate signals -- red, green, and blue.

Another important aspect of a monitor is its screen size. Like televisions, screen sizes are measured in diagonal inches, the distance from one corner to the opposite corner diagonally. These are available in different sizes like 12”, 14”, 15”, 17”,19” and 22” etc. The screen size is sometimes misleading because there is always an area around the edge of the screen that can't be used. Therefore, monitor manufacturers must now also state the viewable area -- that is, the area of screen that is actually used.

Another important aspect of a monitor is resolution. Resolution of a monitor indicates how densely packed the pixels are. In general, more pixels sharper the image. Most modern monitors can display 1134 by 768 pixels, the SVGA standard. Some high-end models can display 1280 by 1134, or even 1600 by 1200.

Maintenance of thé Monitor

Monitor are sensitive to electromagneticwaves, such as mobile phone and audio speakers. Care must be taken to protect your monitor from such disturbances.

Tips: -

1. Turn off the monitor when not in use
2. Keep away devices that emit electromagnetic signals.
3. Do not touch the screen with your hands or sharp objects.
4. Keep UPS/ CVTS away from monitors.
5. Make use of screen savers.

3.6/3.7 Floppy Diskettes/ Hard Disk Drives – These are discussed in the next Unit under the heading Storage devices

3.8 Printers

A device that prints text or illustrations. Printer is the main output device for taking Hard copy (permanent human-readable text and/or graphics) of the required information on documents stored in electronic form, usually on physical print media such as paper or transparencies. Printers vary in size, speed, sophistication and cost. In general, more expensive printers are used for higher-resolution color printing. Printers can be distinguished as impact or non-impact printers.

Impact printers – these printers use a type head which physically hits an inked ribbon. It is pressed against the paper and imprints it. Due to advancements in technology, these printers are no longer being manufactured and the only type of impact printer which is still commonly found today, is the dot matrix printer.

Non-impact printers – these printers use a technique such as ink spray or laser to form a printed copy of the output. In this way characters are not formed by mechanical impact. Normally Non-impact printers produce better quality output than impact printers and they are less noisy.

The printers are generally characterized by the following elements:

Print speed: expressed in pages per minute (ppm), For colour printers, a distinction is generally made between monochrome and colour print speed.

Resolution: Printer resolution (the sharpness of text and images on paper) is usually measured in dots per inch (abbreviated as dpi). Sometimes the resolution is different for a monochrome, colour or photo print-out.

Warm-up time: the waiting time necessary before the first print-out.

Onboard memory: the quantity of memory that allows the printer to store print jobs. The higher the amount of memory, the longer the printer queue can be.

Paper format: depending on their size, printers are able to accept different sized documents.

Paper feed: the method of loading paper into the printer, characterizing the way in which blank paper is stored. The paper feed can change depending on where the printer will be placed (rear loading is advised for printers that will be up against a wall).

Interface: how the printer is connected to the computer. The main interfaces are:

USB, Serial, Parallel, Network. There are also WiFi printers that are available through a wireless network.

There are many different types of printers. In terms of the technology utilized, printers fall into the following categories:

Daisy-wheel: Similar to a ball-head typewriter, this type of printer has a plastic or metal wheel on which the shape of each character stands out in relief. A matrix in the shape of a daisy contains "petals" that each has one raised character. A hammer presses the wheel against a ribbon, which in turn makes an ink stain in the shape of the character on the paper. Daisy-wheel printers produce letter-quality print but cannot print graphics. These printers are known as **Letter Quality Printers (LQP).** These printers are obsolete because they are costly, extremely noisy and very slow.

Dot-matrix: The dot-matrix printer (sometimes called a matrix printer or an impact printer) creates characters by striking pins against an ink ribbon. The head is made up of tiny metal pins (Normally it has 9 or 24 pins), driven by electromagnets, which strike a carbon ribbon called an "inked ribbon", located between the head and the paper. The carbon ribbon scrolls by so that there is always ink on it. At the end of each line, a roller makes the sheet advance. Each pin makes a dot, and combinations of dots form characters and illustrations. Dot Matrix Printers can print any type of text and graphics. On these printers printing of English, Punjabi, Hindi and Pictures etc. can be taken. The most recent dot-matrix printers are equipped with 24-needle printer heads, which allows them to print with a resolution of 216 dpi (dots per inch). Earlier dot-matrix printer was a popular low-cost personal computer printer.

Line Printers : The line printer is a form of high speed impact printer in which one line of type is printed at a time. They are mostly associated with the early days of computing, but the technology is still in use. Print speeds of 600 to 1200 lines-per-minute (approximately 10 to 20 pages per minute) were common.

Page printers : A printer that prints a page at a time. It processes entire page at one time. All laser and ink-jet printers are page printers, which mean that they must have enough memory to store at least one page. The first page printers were huge, floor-standing devices. These are generally a non-impact printers. Such printers require continuous movement of the paper. The information for one page of output is usually accumulated within a buffer in the printer before the printing process is started.

Inkjet Printer and Bubble Jet Printer

Inkjet printers spray ink at a sheet of paper. Ink-jet printers produce high-quality text and graphics. These are based on the principle that a

heated fluid produces bubbles. Today's printer heads are made up of several nozzles (up to 256), equivalent to several syringes, which are heated up to between 300 and 400°C several times per second. Each nozzle produces a tiny bubble that ejects an extremely fine droplet. The vacuum caused by the decrease in pressure creates a new bubble. Inkjet printers use nozzles that have their own built-in heating element. Thermal technology is used here. Bubble jet printers use nozzles that have piezoelectric technology. Each nozzle works with a piezoelectric crystal that changes shape when excited by its resonance frequency and ejects an ink bubble.

Laser Printers

The laser printer produces quality print-outs inexpensively at a high print speed. Laser printer is a popular type of personal computer printer that uses a non-impact (keys don't strike the paper), photocopier technology. When a document is sent to the printer, a laser beam "draws" the document on a selenium-coated drum using electrical charges. After the drum is charged, it is rolled in toner, a dry powder type of ink. The toner adheres to the charged image on the drum. The toner is transferred onto a piece of paper and fused to the paper with heat and pressure. After the document is printed, the electrical charge is removed from the drum and the excess toner is collected. Most laser printers print only in monochrome. A color laser printer is more expensive than a monochrome laser printer. IBM introduced the first laser printer in 1975 for use with its mainframe computers. In 1984, Hewlett-Packard revolutionized laser-printing technology with its first LaserJet, a compact, fast and reliable printer that personal computer users could afford. Since then, laser printers have decreased further in price and increased in quality. Hewlett Packard continues to be the leading manufacturer with competitors including Lexmark, Okidata, and Xerox. The laser printer is different from an inkjet printer in a number of ways. The toner or ink in a laser printer is dry. In an inkjet, it is wet. Over time, an inkjet printer is about ten times more expensive to operate than a laser printer because ink needs replenishing more frequently. The printed paper from an inkjet printer will smear if wet, but a laser-printed document will not. Because both the printers do not have mechanical heads, they operate quickly and quietly and allow fonts to be added by using font cartridges or installing soft fonts. If your printing needs are minimal, an inkjet printer is sufficient. But if your printing volume is high, consider buying a laser printer.

Resolution: The standard resolution in most laser printers today is 600 dots-per-inch (dpi). This resolution is sufficient for normal everyday printing including small desktop publishing jobs. A high-end production printer might have a resolution of 2400 dpi. Some laser printers still use a resolution of 300 dpi. This resolution can cause jagged lines to appear on the outer edge of an image. Hewlett Packard created RET (Resolution Enhancement Technology) to

correct this. RET inserts smaller dots at the edges of lines and to smooth the rough edges. RET does not improve the resolution, but the document looks better.

3.9 Plotters

Plotters are used in the making of hard copy of graphical output. These are used to draw sketch diagrams and designs such as maps and floor maps. Plotters differ from printers in that they draw lines using a pen. As a result, they can produce continuous lines, whereas printers can only simulate lines by printing a closely spaced series of dots. Multicolor plotters use different-colored pens to draw different colors. This means that plotters are restricted to line art rather than creating a solid region of colours like printers. Still, plotters can shade an area by drawing a number of close regular lines. There are two main types of plotters:

Flatbedplotters: In this type of plotter, the paper lies flat on the plotter and a

pen moves along the paper drawing the image. Some flat bed plotters can produce coloured images with the arm retrieving different coloured pens from the side of the plotter. Flatbed plotters are typically used for plotting maps and designing complicated images.

Drum plotters: In this type of plotter, the paper moves vertically (back and forth) by means of rollers while the pen moves horizontally along the paper. Drum

plotters are commonly used in medical environments to plot medical information such as data from electrocardiogram.

Plotters are used for Computer Aided Design (CAD). Plotters can combine text and graphics together. Large images can be printed. Printing is costly and very time consuming. The size of the plotter is big and sufficient space is required for it. In general, plotters are considerably more expensive than printers. They are used in engineering applications where precision is mandatory.

3.10 Voice Response System (Speakers/Headphones)

Through the means of a sound card and speakers, the computer outputs audio signals which produce sound. The initial sound cards were mono; in other words, only one speaker was available; otherwise the sound came out exactly the same from both speakers. The stereo cards followed with two independent sound channels that allowed a sort of sound depth. Finally we are witnessing surround sound systems of the highest quality as available on the best hi-fi equipment.

Headphones (Also known as earphones or headsets) are a pair of small speakers placed in close proximity to the ears that receive an electrical signal from a computer and convert the signal into audible sound waves.

3.11 CD-RW/DVD-RW - These are discussed in the next Unit under the heading Storage devices

3.12 Multimedia Projectors:

LCD Projectors:

LCD projectors project video signals and computer video to the screen. It is a complex electronic device, These are used for displaying images or data. Unlike monitors, projectors can project larger images due to the large screen area. In fact, projectors are used when addressing an audience for advertising, publicity, education or entertainment etc. Projection screens (usually a blank white surface) are used in conjunction with projectors since the best image quality can only be accomplished with a blank white surface to project on.

Advantages: Display can include Its display can include text, graphics and colours; Larger screen size. Small in size and portable.

Disadvantage: Image quality decreases as the size increases.

4. Summary

To communicate with the computer, we need input and output devices. For computer processing, data needs to be entered into the computer through input devices and the result of processing needs to be communicated to the user through output devices. Different output devices are Punched Tape, Punched Cards, Magnetic Tape, Magnetic Drum, Visual Display Units (Monitors), Floppy Diskette, Hard Disk Drive, Printers, Plotters, Voice Response System (Speakers/Headphones), CD - RW/DVD-RW and Multimedia Projector. **Visual Display Units (Monitors)** are normally of two types – CRT (Cathode Ray Tube) and TFT (Thin Film Transistor). Printers are the main output device for taking Hard copy (permanent human-readable text and/or graphics) of the required information on documents stored in electronic form, usually on physical print media such as paper or transparencies. Printers can be classified as Impact and non impact printers. Printers are generally characterized by Print speed, Resolution, Warm-up time, Onboard memory and Interface. Main types of printers are Daisy-wheel, Dot-matrix, Line Printers, Page printers, Inkjet Printer and Bubble Jet Printer, Laser Printers. Plotters are used in the making of hard copy of graphical output. These are used to draw sketch diagrams and designs such as maps and floor maps. Important types of plotters are Flatbed and Drum type. Voice Response Systems (Speakers/Headphones) are also used as output devices.

5. Keywords

Keywords of this lesson are **"Output devices, Visual Display Units (Monitors), Printers, Plotters, Voice Response System (Speakers/Headphones), CD - RW/DVD-RW, Multimedia Projector and Plotters".** These have been explained briefly in the summary.

6. Short answer type Questions

1. Name the different output devices.
2. Write short notes on the any of three following input devices.
    - Punched Tape
    - Punched Cards
    - Visual Display Units (Monitors)
    - Printers
    - Plotters
    - Voice Response System (Speakers/Headphones)
    - Multimedia Projector
3. What is the difference between impact and non-impact printers ?

7. Long answer type Questions

1. What are the different output devices. Explain the function of each.
2. Describe the different types of plotters.
3. What is the use of printer. What type of printers are available.

8. Suggested Readings

- Information Technology by Satish Jain
- Information Technology and Management by Turban Mclean and Wetbrete
- Computer Fundamentals by Pradeep Kumar Sinha and Priti Sinha
- Fundamentals of Computer by V.Rajaraman, PHI, India.

LESSON NO. 6 **AUTHOR: JAGMOHAN SINGH JUNEJA**
CONVERTED INTO SLM BY: DR. VISHAL SINGH

MEMORY

1. Objectives

Objectives of this lesson are to understand the importance of memory, units to measure it, different types of memories – technology and functionality wise.

2. Introduction

As already explained in previous lessons that computer consists of Primary/Main memory and secondary memory. Main memory is the electronic place for holding the instructions and data that computer's microprocessor can reach quickly. Before proceeding further, we need to refresh some of the terms, which are covered in the previous unit.

3. Some basic definitions

Bit:

Computer stores a variety of data and information in its memory, including numbers (0-9), letters (A-Z), symbols and other characters (#,{},',~,^). A computer uses the *binary system* to represent these characters. In a binary system, only two digits, 0 and 1 are used. The 0's and 1's in the binary system are known as bits. A bit is a binary digit, taking a value of either 0 or 1. Binary digits are a basic unit of information storage and communication in digital computing and digital information theory.

Byte:

A byte is the basic unit of measurement of information storage in computer science. In many computer architectures it is a unit of memory addressing, most often consisting of eight bits. A byte is one of the basic integral data types in some programming languages, especially system programming languages.

A byte is an ordered collection of bits, with each bit denoting a single binary value of 1 or 0. The size of a byte can vary and is generally determined by the underlying computer operating system or hardware, although the 8-bit byte is the standard in most of the systems. Historically, byte size was determined by the number of bits required to represent a single character from a Western character set. Its size was generally determined by the number of possible characters in the supported character set and was chosen to be a divisor of the computer's word size. Historically bytes have ranged from five to twelve bits.

Since computer memory comes in a Power of two rather than 10, a large portion of the software and computer industry use binary estimates of the quantities,

4. Units to measure the capacity of memory

Bit, Byte, Kilobytes, Megabytes, Gigabytes and Terabytes are the units for measuring the capacity of memory or storage devices. Bit is the smallest unit of memory, which can store either 0 or 1. To understand the relationship between them, please refer the following tables.

8 bits	=	1 byte
1134 bytes	=	1 kilobyte (KB)
1134 KB	=	1 megabyte (MB)
1134 MB	=	1 gigabyte (GB)
1134 GB	=	1 terabyte (TB)

8bits	2^0 * 8 bits	=	1 byte	=	1 byte
2^{10} bytes	2^{10}*8 bits	=	1134 bytes	=	1 Kilobyte (KB)
2^{10} KB	2^{20}*8 bits	=	1134 KB	=	1 Megabyte (MB)
2^{10} MB	2^{30}*8 bits	=	1134 MB	=	1 Gigabyte (GB)
2^{10} GB	2^{40} * 8 bits	=	1134 GB	=	1 Terabyte (TB)

5. Units for Measurement of Speed

In computer science speed is measured in

Millisecond (ms or msec) is one thousandth **(10^{-3})**of a second and is commonly used for measuring the time to read to or write from a hard disk or a CD-ROM player or to measure packet travel time on the Internet.

Microsecond is one millionth **(10^{-6})** of a second.

Nanosecond (ns or nsec) is one billionth **(10^{-9})** of a second and is a common measurement of read or write access time to random access memory (RAM).

Pico-second is one trillionth **(10^{-12})** of a second or one millionth of a microsecond.

Femtosecond is one millionth of a nanosecond or **(10^{-15})** of a second and is a measurement sometimes used in laser technology.

Attosecond is one quintillionth **(10^{-18})** of a second and is a term used in photon research.

6. Access and Access time

Normally access means to read data from or write data to a mass storage device. The time interval between the instant at which information is called from the storage and instant at which delivery is completed is known as Access time.

7. Random and Sequential access

Random access (sometimes called direct access) is the ability to access an arbitrary element in a sequence in equal time. The opposite is sequential access, where a remote element takes longer time to access. Sequential access means retrieving data serially starting from the beginning. A typical illustration of this distinction is to compare an ancient scroll (sequential; all material prior to the data needed must be unrolled) and the book (random: can be immediately flipped open to any random page. A more modern example is a cassette tape (sequential—you have to fast-forward through earlier songs to get to later ones) and a compact disc (random access—you can jump right to the track you want). In the Payroll system, where we have to prepare the salary of every employee, sequential access of data is better but if we have to find the information of one employee from the database then random access is better. These terms are relevant to memory and storage devices.

8. Primary Memory

The primary memory or the main memory is part of the main computer system. The processor or the CPU directly stores and retrieves information from it. This memory is accessed by CPU, in random fashion. Normally primary memory is of type RAM, ROM, Cache etc.

9. Secondary Memory

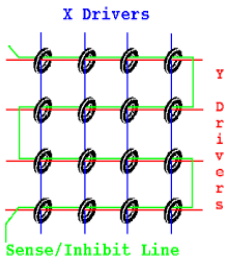
Secondary memory (or secondary storage) is the cheapest form of memory. It is also called auxiliary memory. Secondary memory unlike primary memory is much slower but is far more cost effective and stores the data permanently unless it is erased. Secondary memory devices include magnetic tapes, magnetic disks like hard drives and floppy disks ; optical disks such as CDs and CDROMs

10. Type of Computer Memories - On the basis of technology:

Main memory unit is an extremely important part of any computer. Many types of memories have been developed and used over the years. The earliest memory units consisted of vacuum tubes (diodes). These were used in first generation systems, like ENIAC. A memory unit could not be prepared having large number of tubes due to size considerations. Because of this, the memory size was very small. Such memories were bulky and very slow. Alternative memory elements have been developed. Commonly used are magnetic cores and semi conductor memories.

10.1 Magnetic core memory:

Magnetic core memory, or ferrite-core memory, is an early form of computer memory. It uses small magnetic ceramic rings, the cores, to store information via the polarity of the magnetic field they contain. Such memory is often just called core memory, Magnetic core memories were used for quite a long time. Many of the third generation computers used this type of memory. A magnetic core can be magnetized clockwise or anti-clockwise



10.2 Semiconductor Memory :

Semiconductor memory consists of electronic circuits prepared on silicon- chips. The electronic circuit is called a Flip - flop. A flip-flop, circuit can store either 1 or 0, that is, it is a two-state element. A flip-flop is also called a ***Storage, cell.*** Thousand of these storage cells can be prepared on a single silicon chip. Due to this, the physical size of the semiconductor memories is very small. Moreover, their cost is decreasing every year as the fabrication technology is advancing. These are the devices for storing digital information that are fabricated by using integrated circuit technology. Semiconductor memories are widely used to store programs and data in almost every digital system and have replaced core memory as the main active computer memory.

11. Classification of memories on the basis of functionality

On the basis of functionality, computers can also be classified into different types of categories like Random/Sequential, RAM, ROM, PROM, EPROM, Flash and Cache etc.

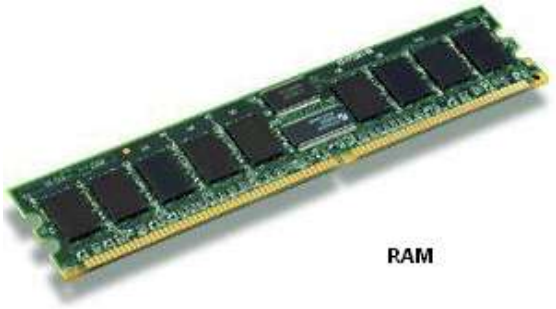
12. Sequential and Random Access Memories :

Sequential access memory means that information stored in the computer memory can be reached only by starting at the first memory location, then next, then next, in the order till the desired location where information is stored.

Random access memory indicates that the information stored anywhere in the memory can be reached directly. There is no step by step scan involved in this. Magnetic core and semiconductor memories are examples of this. Generally, Random Access Memories are much faster than sequential access memories.

13. Random Access Memory (RAM) :

As the name suggests, it is a Random access type memory. Information can be read or written into the memory at random. It is also called, a Read/Write memory. It is a volatile memory, that is, information stored there is lost when the electrical power to the circuit is switched of. Normally, user programs and data are stored in RAM. Memory is often used as a shorter synonym for random access memory (RAM). RAM is a place, where the operating system, application programs and data in current use are kept so that they can be quickly reached by the computer's processor. It is used while the computer is on to retrieve recently accessed files, run applications and performs other tasks. It is a chip that can be upgraded to larger capacity. RAM allows information to be stored or accessed in any order. RAM is much faster to read from and write to than the other kinds of storage in a computer, the hard disk, floppy disk, and CD-ROM. RAM a memory chip is an integrated circuit (IC) made of millions of transistors and capacitors and they (transistors and capacitors are paired to create a memory cell, which represents a single bit of data. The capacitor holds the bit of information -- a 0 or a 1.



RAM

RAM can be compared to a person's short-term memory and the hard disk to the long-term memory. The short-term memory focuses on work at hand, but can only keep so many facts in view at one time. If short-term memory fills up, your brain sometimes is able to refresh it from facts stored in long-term memory. A computer also works this way. If RAM fills up, the processor needs to continually go to the hard disk to overlay old data in RAM with new, slowing down the computer's operation. Unlike the hard disk which can become completely full of data so that it won't accept any more, RAM ever runs out of memory. It keeps operating, but much more slowly than you may want it to. RAM is small, both in physical size (it's stored in microchips) and in the amount of data it can hold. It's much smaller than the hard disk. A typical computer may come with 256 million bytes of RAM and a hard disk that can hold 40 billion bytes. RAM comes in the form of "discrete" (meaning separate) microchips and also in

the form of modules that plug into holes in the computer's motherboard. These holes connect through a bus or set of electrical paths to the processor. The hard drive, on the other hand, stores data on a magnetized surface that looks like a phonograph record.

Most personal computers are designed to allow you to add additional RAM modules up to a certain limit. Having more RAM in the computer reduces the number of times that the computer processor has to read data in from the hard disk, an operation that takes much longer than reading data from RAM. (RAM access time is in nanoseconds; hard disk access time is in milliseconds.)

Following are the some of the popular types of RAM, which are being used.

13.1 DRAM

Dynamic random access memory (DRAM) is a type of random access memory that stores each bit of data in a separate capacitor within an integrated circuit. Since real capacitors leak charge, the information eventually fades unless the capacitor charge is refreshed periodically. Because of this refresh requirement, it is a dynamic memory as opposed to SRAM and other static memory. Its advantage over SRAM is its structural simplicity: only one transistor and a capacitor are required per bit, compared to six transistors in SRAM. This allows DRAM to reach very high density. Like SRAM, it is in the class of volatile memory devices, since it loses its data when the power supply is removed.

13.2 SRAM

Static random access memory (SRAM) is a type of semiconductor memory. The word "static" indicates that the memory retains its contents as long as power remains applied, unlike dynamic RAM (DRAM) that needs to be periodically refreshed (nevertheless, SRAM should not be confused with read-only memory and flash memory, since it is volatile memory and preserves data only while power is continuously applied).

13.3 SDRAM

Short for Synchronous DRAM, a type of DRAM that can run at much higher clock speeds than conventional memory. SDRAM actually synchronizes itself with the CPU's bus

13.4 DDR-SDRAM

Short for Double Data Rate-Synchronous DRAM, a type of SDRAM that supports data transfers on both edges of each clock cycle (the rising and falling edges), effectively doubling the memory chip's data throughput. DDR-SDRAM also consumes less power, which makes it well-suited to notebook computers.

14. Read Only Memory (ROM) :

ROM is "built-in" computer memory containing data that normally can only be read, not written to. Data can be read from the memory but cannot be written there. This is why its name is Read Only Memory. ROM contains the programming that allows your computer to be

"booted up" or regenerated each time you turn it on. Unlike a computer's random access memory (RAM), the data in ROM is not lost when the computer power is turned off. Therefore it is called as non-volatile memory. In **ROM**, information is written permanently into the memory. It cannot be changed easily. ROMs are normally used to store information that the computer may need frequently for its own operation.

Besides RAM and ROM, following are the other special forms of semi-conducting memories. These are, used in microcomputers and personal computers for special purposes.

14.1 PROM (Programmable, Read Only Memory)

Programmable read-only memory (PROM) is read-only memory (ROM) that can be modified once by a user. PROM is a way of allowing a user to tailor a microcode program using a special machine called a PROM programmer. This machine supplies an electrical current to specific cells in the ROM that effectively blows a fuse in them. The process is known as burning the PROM.

14.2 EPROM (Erasable programmable read-only memory)

EPROM is programmable read-only memory (programmable ROM) that can be erased and re-used. Since the burning of PROM leaves no margin for error, most ROM chips designed to be modified by users use erasable programmable read-only memory. Erasure is caused by shining an intense ultraviolet light through a window that is designed into the memory chip. (Although ordinary room lighting does not contain enough ultraviolet light to cause erasure, bright sunlight can cause erasure. For this reason, the window is usually covered with a label when not installed in the computer.

14.3 EEPROM (Electrically erasable programmable read-only memory)

EEPROM is user-modifiable read-only memory (ROM) that can be erased and reprogrammed (written to) repeatedly through the application of higher than normal electrical voltage. Unlike EPROM chips, EEPROMs do not need to be removed from the computer to be modified. However, an EEPROM chip has to be erased and reprogrammed in its entirety, not selectively. It also has a limited life - that is, the number of times it can be reprogrammed is limited to tens or hundreds of thousands of times.

15. Flash memory

(sometimes called "flash RAM") is a type of constantly-powered non-volatile memory that can be erased and reprogrammed in units of memory called blocks. Flash memory is often used to hold control code such as the basic input/output system (BIOS) in a personal computer. When BIOS needs to be changed (rewritten), the flash memory can be written to in block (rather than byte) sizes, making it easy to update. On the other hand, flash memory is not as useful as random access memory (RAM) because RAM needs to be addressable at the byte (not the block) level. Flash memory gets its name because the microchip is organized so that a section of memory cells are erased in a single action or "flash." Flash memory is used in digital cellular phones, digital cameras, LAN switches, PC Cards for notebook computers, digital set-up boxes, embedded controllers and other devices.

16. Cache Memory

It is random access memory that a computer microprocessor can access more quickly than it can access regular RAM. Pronounced cash, a special high-speed storage mechanism. It can be either a reserved section of main memory or an independent high-speed storage device. Two types of caching are commonly used in personal computers: memory caching and disk caching.

17. Memory caching

A memory cache, sometimes called a cache store or RAM cache, is a portion of memory made of high-speed static RAM (SRAM) instead of the slower and cheaper dynamic RAM (DRAM) used for main memory. Memory caching is effective because most programs access the same data or instructions over and over. By keeping as much of this information as possible in SRAM, the computer avoids accessing the slower DRAM. Some memory caches are built into the architecture of microprocessors. The Intel 80486 microprocessor, for example, contains an 8K memory cache, and the earlier Pentium had a 16K cache. Such internal caches are often called Level 1 (L1) caches. Most modern PCs also come with external cache memory, called Level 2 (L2) caches. These caches sit between the CPU and the DRAM. Like L1 caches, L2 caches are composed of SRAM but they are much larger. Now-a-days computer have normally 1 or 2 MB cache memory.

18. Disk caching

Disk caching works under the same principle as memory caching, but instead of using high-speed SRAM, a disk cache uses conventional main memory. The most recently accessed data from the disk (as well as adjacent sectors) is stored in a memory buffer. When a program needs to access data from the disk, it first checks the disk cache to see if the data is there. Disk caching can dramatically improve the performance of applications, because accessing a byte of data in RAM can be thousands of times faster than accessing a byte on a hard disk.

When data is found in the cache, it is called a cache hit, and the effectiveness of a cache is judged by its hit rate. Many cache systems use a technique known as smart caching, in which the system can recognize certain types of frequently used data. The strategies for determining which information should be kept in the cache constitute some of the more interesting problems in computer science.

19. Summary

A bit is a binary digit, taking a value of either 0 or 1. Binary digits are a basic unit of information storage and communication in digital computing and digital information theory. A byte is an ordered collection of bits, with each bit denoting a single binary value of 1 or 0. Bit, Byte, Kilobytes, Megabytes, Gigabytes and Terabytes are the units for measuring the capacity of memory. In computer science speed is measured in **Millisecond, Microsecond, Nanosecond, Picosecond and Femtosecond.** Magnetic core memory, or ferrite-core memory, is an early form of computer memory. It uses small magnetic ceramic rings, the cores, to store information. Semiconductor memory consists of electronic circuits prepared on

silicon- chips. **RAM,** as the name suggests, is a Random access type memory. Information can be read or written into the memory at random. RAM a memory chip is an integrated circuit (IC) made of millions of transistors and capacitors. Dynamic random access memory (DRAM) is a type of random access memory that stores each bit of data in a separate capacitor within an integrated circuit. Static random access memory (SRAM) is a type of semiconductor memory. The word "static" indicates that the memory retains its contents as long as power remains applied. **SDRAM is** a type of DRAM that can run at much higher clock speeds than conventional memory. SDRAM actually synchronizes itself with the CPU's bus. **DDR-SDRAM** is a type of SDRAM that supports data transfers on both edges of each clock cycle (the rising and falling edges), effectively doubling the memory chip's data throughput. ROM is "built-in" computer memory containing data that normally can only be read, not written to. Data can be read from the memory but cannot be written there. **PROM -** Programmable read-only memory is a read-only memory that can be modified once by a user. EPROM is programmable read-only memory (programmable ROM) that can be erased and re-used. EEPROM is user-modifiable read-only memory (ROM) that can be erased and reprogrammed (written to) repeatedly through the application of higher than normal electrical voltage. **Flash memory** (sometimes called "flash RAM") is a type of constantly-powered non-volatile memory that can be erased and reprogrammed in units of memory called blocks. **Cache Memory -** Pronounced cash is a special high-speed storage mechanism. It can be either a reserved section of main memory or an independent high-speed storage device.

20. Keywords

Keywords of this lesson are **Bit, Byte, Millisecond, Microsecond, Nanosecond, Picosecond, Femtosecond, Attosecond, Access time, Random and Sequential access, Primary Memory, Secondary Memory, Magnetic core memory, Semiconductor Memory, RAM, DRAM, SRAM, SDRAM, DDR-SDRAM, ROM, PROM, EPROM, EEPROM, Flash and Cache Memory.**

21. Short answer type Questions

1. Differentiate between Access and Access time.
2. Differentiate between Random and Sequential access.
3. Differentiate between Primary Memory and Secondary Memory
4. Differentiate between RAM and ROM.
5. Differentiate between Bit and Byte
6. Describe the units to measure the memory

22. Long answer type Questions

1. What is memory? Describe the different type of memories.
2. Write short notes on RAM, ROM, DRAM, SRAM, PROM AND EPROM.

23. Suggested Readings

- Information Technology by Satish Jain
- Information Technology and Management by Turban Mclean and Wetbrete
- Computer Fundamentals by Pradeep Kumar Sinha and Priti Sinha

LESSON NO. 7 **AUTHOR: JAGMOHAN SINGH JUNEJA**
CONVERTED INTO SLM BY: DR. VISHAL SINGH

STORAGE DEVICES

1. Objectives

Objectives of this lesson are to discuss the various types of storage devices.

2. Introduction

***Computer storage* refers to the data stored in an electromagnetic form to be used by the processor**. The amount of data stored on a computer can be measured just as we can measure the amount of water in a container, although measurement units are different. The *storage capacity* defines the amount of data that can be stored on a storage device. Units to measure the memory or storage capacity have been discussed in earlier lesson.

Normally, when we talk about memory, we mean the primary memory, when we talk about storage, we mean the secondary memory. Various types of primary memories have been discussed in the previous lesson. In this lesson, we will discuss about the various devices, which are used for secondary storage devices. These are the physical mediums that hold the much larger amounts of data that won't fit into RAM and may not be immediately needed there.

Commonly storage devices include hard disks, floppy disks, CD-ROM, DVD and Pen drives. The terms auxiliary storage, auxiliary memory and secondary memory have also been used for this kind of data repository. There are number of devices which can be used as input, output and storage purposes. Following are some of the commonly used storage devices. These devices can be used to store the information permanently. The main advantages of these are that these devices can store the huge amount of information and data and very less space is required to store these.

- **Punched Paper Tape**
- **Punched Cards**
- **Paper**
- **Magnetic Tape**
- **Magnetic Drum**
- **Floppy Diskette**
- **Hard Disk Drive**
- **Compact Disk**
- **DVD**
- **USB/Pen drives**

3. Random and Sequential Storage devices

As already explained in the previous lesson, that some of the storage devices are random storage devices and some are sequential devices.

4. Storage Devices

4.1 Punched Paper Tape – Already discussed in previous lessons.

4.2 Punched Cards – Already discussed in previous lessons.

4.3 Paper

It is the most common and convenient method to store the information permanently. Normally printers and plotters are used to store the information on this media. Drawback of this is, once this medium is used, it cannot be re-used.

4.4 Magnetic Tape

A sequential storage medium used for data collection, backup and archiving. Like videotape, computer tape is made of flexible plastic with one side coated with a ferromagnetic material. Tapes were originally open reels, but were superseded by cartridges and cassettes of many sizes and shapes.

Tape has been more economical than disks for archival data, but that is changing as disk capacities have increased enormously. If tapes are stored for the duration, they must be periodically recopied or the tightly coiled magnetic surfaces may contaminate each other.

The major drawback of tape is its sequential format. Locating a specific record requires reading every record in front of it or searching for markers that identify predefined partitions.

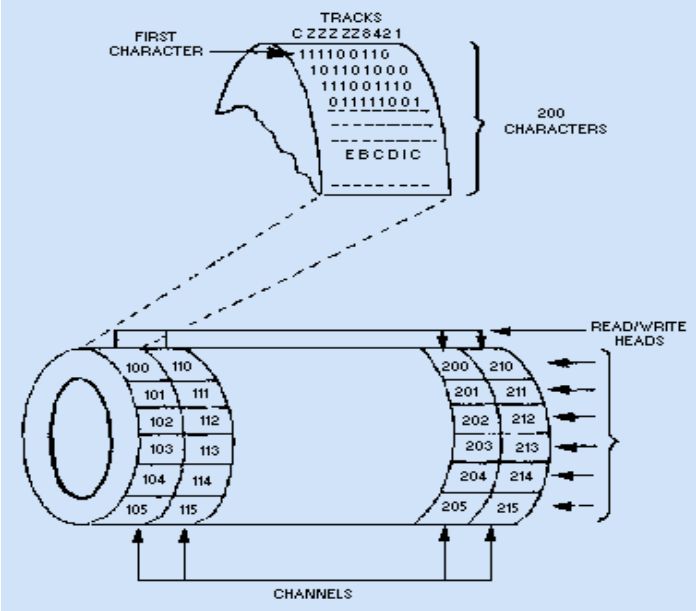
Although most tapes are used for archiving rather than routine updating, some drives allow rewriting in place if the byte count does not change. Otherwise, updating requires copying files from the original tape to a blank tape (scratch tape) and adding the new data in between.

Open reel tapes used nine linear tracks (8 bits plus parity), while modern cartridges use 128 or more tracks. Data are recorded in blocks of contiguous bytes, separated by a space called an "inter-record gap" or "inter-block gap." Tape drive speed is measured in inches per second (ips). Over the years, storage density has increased from 200 to 38,000 bpi. Now-a-days these are not in much use.

4.5 Magnetic Drum

An early high-speed, direct access storage device that used a magnetic-coated cylinder with tracks around its circumference. Each track had its own read/write head. Magnetic drums were used in the 1950s and 1960s.

The tracks on a magnetic drum are assigned to channels located around the circumference of the drum, forming adjacent circular bands that wind around the drum. A single drum can have up to 200 tracks. As the drum rotates at a speed of up to 3,000 rpm, the device's read/write heads deposit magnetized spots on the drum during the write operation and sense these spots during a read operation. This action is similar to that of a magnetic tape or disk drive.



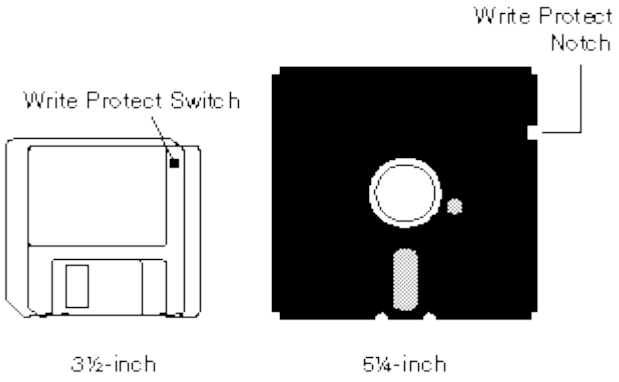
Unlike some disk packs, the magnetic drum cannot be physically removed. The drum is permanently mounted in the device. Magnetic drums are able to retrieve data at a quicker rate than tape or disk devices but are not able to store as much data as either of them. Now-a-days these are not used.

4.6 Floppy Disk

A soft magnetic disk. It is called floppy because it flops if you wave it (at least, the 5¼-inch variety does). Unlike most hard disks, floppy disks (often called floppies or diskettes) are portable, because you can remove them from a disk drive. Floppy disk drive (FDD), a disk drive that can read and write to floppy disks. Just like as we have at homes tape recorders and tape, where tape is media and Tape recorder is a device. Similarly for FDD - floppy diskette is media and Floppy disk drive is the device. Floppy diskettes come in different sizes with different capacities.

Floppy Disk Drive

A floppy disk looks like a phonogram record. It is provided with a protective card board envelope. Usually Floppies come in $5^1/_4$ ” and 3.5 ” sizes in capacities of 360 KB, 1.2 MB and 1.44 MB. Different types of Floppies have different tracks like 48 TPI, 96 TPI. TPI stands for Tracks per inch. Some Floppies are Single Side Single Density (SSSD), some are Double Side Double Density (DSDD) and some are Double Side High Density (DSHD). Floppy disk drive is a random access device.



Floppies come in three basic sizes:

8-inch: The first floppy disk design, invented by IBM in the late 1960s and used in the early 1970s as first a read-only format and then as a read-write format.

5¼-inch: The common size for PCs made before 1987 and the predecessor to the 8-inch floppy disk. This type of floppy is generally capable of storing between 100K and 1.2MB (megabytes) of data. The most common sizes are 360K and 1.2MB.

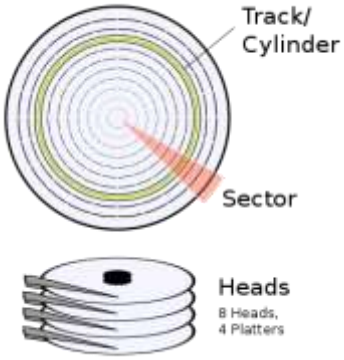
3½-inch: Floppy is something of a misnomer for these disks, as they are encased in a rigid envelope. Despite their small size, microfloppies have a larger storage capacity than their cousins -- from 400K to 1.4MB of data. The most common sizes for PCs are 720K (double-density) and 1.44MB (high-density).

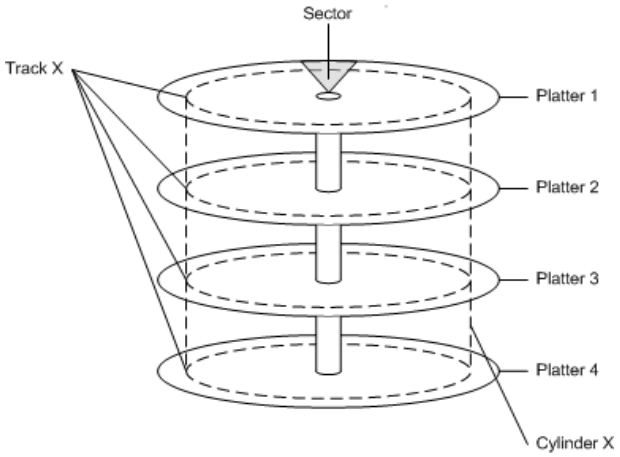
As per specifications of Floppy disk drive (FDD) corresponding floppy diskettes must be used. However in 1.2 MB floppy disk drive floppy diskettes of 360 KB and 1.2 MB capacity both can be used but in 360 KB FDD only 360 KB floppy diskette can be used.

Now-a-days these are not in much use.

4.7 Hard Disk Drive

Hard disk drive is a sealed box consisting of number of magnetic disks and having storage capacity much more than floppy diskette. Normally hard disk is part of a computer. It





provides relatively quick access to large amounts of data onan electromagnetically charged surface or set of surfaces. Today's computers typically come with a hard disk that contains several billion bytes (gigabytes) of storage. Earlier capacity of HDD was 20 MB, 40 MB, 80 MB and so on but now-a-days capacity of HDD is normally 160 GB, 320 GB etc. It is faster and much more reliable than the floppy diskette. Hard disk usually consists of several platters. Each platter requires two read/write heads, one for each side. All the read/write heads are attached to a single access arm so that they cannot move independently. Each platter has the same number of tracks, and a track location that cuts across all platters is called a cylinder. For example, a typical 84 megabyte hard disk for a PC might have two platters (four sides) and 1,053 cylinders. A hard disk/drive unit comes with a set rotation speed varying from 4500 to 7200 rpm. Disk access time is measured in milliseconds. Although the physical location can be identified with cylinder, track and sector locations, these are actually mapped to a logical block address (LBA) that works with the larger address range on today's hard disks.

Portable hard disk drive

A disk drive that is plugged into an external port on a computer such as USB or FireWire. Typically used for backup, but also as secondary storage, such units rival internal drives in capacity. For laptops, the PC Card slot may be used to connect a cable to a full-size drive, or the hard disk may be contained entirely inside the PC Card.

USB Hard Disk Drive

It is a portable hard disk drive fitted in a safe case having USB Connectivity. A Laptop has also this type of Hard disk. It is faster and reliable than pen drives. The only caution is to handle it with care.

Normally these are available in the capacities 160GB, 250GB, 320GB and 400GB etc.

4.8 Compact Disk

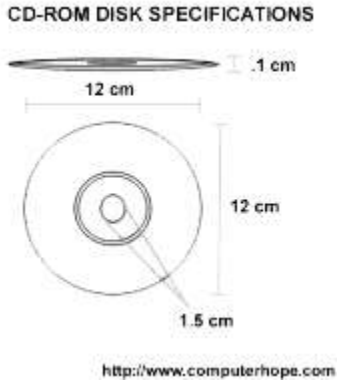
Sometimes it is also called an optical disc. A nonmagnetic, polished metal disk used to store digital information. The disk is read by a optical scanning mechanism that used a high-intensity light source, such as a laser and mirrors.

A compact disc [sometimes spelled disk] (CD) is a small, portable, round medium made of molded polymer (close in size to the floppy disk) for electronically recording, storing, and playing back audio, video, text and other information in digital form. CDs have replaced the phonograph record and tape recorders for playing back music. At home, CDs have tended to replace the tape cartridge although the latter is still widely used in cars and portable playback devices.

Initially, CDs were read-only, but newer technology allows users to record as well. CDs will probably continue to be popular for music recording and playback. A newer technology, the digital versatile disc (DVD), stores much more in the same space and is used for playing back movies.

CD ROM

(Compact Disc, read-only-memory) - is an adaptation of the CD that is designed to store computer data in the form of text and graphics, as well as hi-fi stereo sound. CD-ROM is a drive which reads aluminum-coated round plastic discs, however does not write to the discs. Similar to FDD, Diskette or disk or disc is the media and to read or write on this, we need the corresponding drive.



Standard CD-ROM diskettes are 120 mm (4.75 inches) in diameter and 1.2 mm (0.05 inches) thick. The diskette is made of a polycarbonate wafer and is coated with a metallic film, usually an aluminum alloy. This aluminum film is the portion of the disc that the CD-ROM drive reads for information. The aluminum film is then covered by a plastic polycarbonate coating that protects the underlying data. A label will usually be placed on the top of the disc and data is read from the bottom of the CD.

Today, CD-ROMs are standardized and work in any standard CD-ROM drive. CD-ROM drives can also read audio compact discs for music, although CD players cannot read CD-ROM discs.

The CD-ROM, like other CD adaptations, has data encoded in a spiral track beginning at the center and ending at the outermost edge of the disc. The spiral track holds approximately 650 MB of data. That's about 5.5 billion bits. The distance between two rows of pits, measured from the center of one track to the center of the next track is referred to as track pitch. The track pitch can range from 1.5 to 1.7 microns, but in most cases is 1.6 microns.

Constant Linear Velocity (CLV) is the principle by which data is read from a CD-ROM. This principal states that the read head must interact with the data track at a constant rate, whether it is accessing data from the inner or outermost portions of the disc. This is affected by varying the rotation speed of the disc, from 500 rpm at the center, to 200 rpm at the outside. In a music CD, data is read sequentially, so rotation speed is not an issue. The CD-ROM, on the other hand, must read in random patterns, which necessitates constantly shifting rotation speeds. Pauses in the read function are audible and some of the faster drives can be quite noisy because of it.

CD-R –

(*CD Recordable)* – On these types of diskettes data can be written only once. Once it is written, it cannot be erased.

CD-RW

(Compact disc, rewriteable) is a compact disc (CD) format that allows repeated recording on a disc. Now any user with a CD Recorder drive could create their own CDs from their desktop computers. CD-RW drives can write both CD-R and CD-RW discs and can read any type of CD. Only drives designated as "Multi Read" can read CD-RW diskettes reliably.

CD-RW discs usually hold 74 minutes (650 MB) of data, although some can hold up to 80 minutes (700 MB) and, according to some reports, can be rewritten as many as 1000 times. With packet writing software and a compatible CD-RW drive, it is possible to save data to a CD-RW in the same way as one can save it to a floppy disk. CD recorders (usually referred to as CD burners), were once much too expensive for the home user, but now are similar in price to CD-ROM drives. CD-RW drive is a popular alternative to the CD-R drive.


CD Rom

4.9 DVD

Digital Video Disc or Digital Versatile Disc - An optical digital disc for storing movies and data. disc uses the same diameter platter as a CD (120mm/4.75" diameter), but holds 4.7GB (of digital information on a single-sided, single-layer disc) rather than 700MB. High-density double-sided compact disc can store up to 17 gigabytes of digital data-roughly the equivalent of 24 CDs. It is a better medium for distributing feature-length films than videocassettes,

Whereas CDs use only one side, DVDs can be recorded on both sides as well as in dual layers. DVD drives/players can read most CD media as well.

Originally these were named as **"Digital Video Disc."** Since the technology became important to the computer world, the "video" was dropped, and it was dubbed as **"Digital Versatile Disc"** by the DVD Forum.

Read-Only Data DVDs - DVD-ROM.

Designed for data files, a DVD-ROM disc is a higher-capacity CD-ROM, and like CD-ROMs, DVD-ROMs are manufactured.

Writable/Recordable Data DVDs - DVD-RAM

A DVD-RAM is a rewritable DVD that functions like a removable hard disk. *It* uses a phase-change technology like the CD-RW drives. DVD-RAM media can be rewritten 100,000 times before they are no longer usable. DVD-RAM discs cannot be read by standard DVD-ROM drives because of the differences in both reflectivity of the medium and the data format.

DVD-R and DVD+R are competing write-once formats for movies or data. DVD-RW and DVD+RW are competing rewritable (re-recordable) formats that unlike DVD-RAM's 100,000 cycles, can only be rewritten 1,000 times. Aimed at the consumer, 1,000 rewrites is considered more than sufficient.

Music DVDs - DVD-Audio

DVD-Audio is a second-generation digital music format that provides higher sampling rates than audio CDs.

DVD-Video is the movie format, which uses MPEG-2 compression to provide approximately two hours of video per side at standard definition TV resolution (480i resolution). When most people mention the word "DVD," they are referring to a DVD-Video disc.

The Comparison table may be as follows

Floppy Disk	Hard Disk	CD-ROM	DVD
Referred as Floppy	Referred as fixed disk	Referred as compact disk	Referred as digital versatile disk
Is removable	Is usually attached within the system unit	Is removable	Is removable
Made of flexible vinyl material, Less resistant to damage by heat, dust and magnetic fields	Less prone to damage, since packed airtight	Reliable because data cannot be altered without CD writer	Reliable because data cannot be altered without DVD writer
Has capacity of 1.44 MB	Sizes are 40, 80, 120, 160, 200, 250 and 500 GB and so on	Can store 650 MB-700 MB	Can store at least 4.7 GB
Can be used to read write data	Can be used to read write data	Is read only (i.e., data once written cannot be erased or overwritten)	Is read only

4.10 USB drives/Pen Drives

A flash memory card that plugs into the computer's USB port. Small enough to hook onto a keychain, it emulates a small disk drive and allows data to be easily transferred from one machine to another. Software drivers are not required for the latest operating systems, but are available on the Web for legacy systems such as Windows 98, Windows NT and Mac OS 8.

Pen drive is a small, portable flash memory card that plugs into a computer's USB port and functions as a portable hard drive. USB flash drives are easy-to-use as they are small enough to be carried in a pocket and can plug into any computer. USB flash drives have less storage capacity than an external hard drive, but they are smaller and more durable because they do not contain any internal moving parts.

USB flash drives also are called thumb drives, jump drives, pen drives, key drives, tokens or simply USB drives.

Wireless USB

The wireless version of the universal serial bus (USB). Using ultra-wideband (UWB) technology, wireless USB is designed to provide the same 480 Mbits/sec data rate as USB 2.0 within two meters (6.6 ft.) or 110 Mbps within 10 meters (33 ft.). Although it can be used with desktop computers, wireless USB makes it easy to connect and disconnect USB peripherals from a laptop.

5. Summary

Paper is the most common and convenient method to store the information permanently. Normally printers and plotters are used to store the information on this media. Drawback of this is, once this medium is used, it cannot be re-used. **Magnetic Tape** is a sequential storage medium used for data collection, backup and archiving. Like videotape, computer tape is made of flexible plastic with one side coated with a ferromagnetic material. **Magnetic Drum** is an early high-speed, direct access storage device that used a magnetic-coated cylinder with tracks around its circumference. Each track had its own read/write head. **Floppy disk drive (FDD)** is a drive that can read and write to floppy disks. A floppy disk looks like a phonogram record. It is provided with a protective card board envelope. Usually Floppies come in $5^1/_4$ ” and 3.5 ” sizes in capacities of 360 KB, 1.2 MB and 1.44 MB. **Hard disk drive** is a sealed box consisting of number of magnetic disks and having storage capacity much more than floppy diskette. Normally hard disk is part of a computer. It provides relatively quick access to large amounts of data on an electromagnetically charged surface or set of surfaces. **Portable hard disk drive** is a drive that is plugged into an external port of a computer such as USB or FireWire. **USB Hard Disk Drive** is a portable hard disk drive fitted in a safe case having USB Connectivity. It is faster and reliable than pen drives. The only caution is to handle it with care. **Compact Disk** is also called optical disc. A nonmagnetic, polished metal disk used to store digital information. The disk is read by a optical scanning mechanism that use a high-intensity light source, such as a laser, and mirrors. A compact disc [sometimes spelled disk] (CD) is a small, portable, round medium made of molded polymer (close in size to the floppy disk) for electronically recording, storing, and playing back audio, video, text, and other information in digital form. **CD ROM** is an adaptation of the CD that is designed to store computer data in the form of text and graphics, as well as hi-fi stereo sound.**CD-R -** (*CD Recordable)* – On these types of diskettes data can be written only once. Once it is written, it cannot be erased. **CD-RW** (Compact disc, rewriteable) is a compact disc (CD) format that allows repeated recording on a disc. **DVD (**Digital Versatile Disc) is an optical digital disc for storing movies and data. disc uses the same diameter platter as a CD (120mm/4.75" diameter), but holds 4.7GB (of digital information on a single-sided, single-layer disc) rather than 700MB. High-density double-sided compact disc can store up to 17 gigabytes of digital data-roughly the equivalent of 24 CDs. It is a better medium for distributing feature-length films than videocassettes. DVDs can be recorded on both sides as well as in dual layers. DVD drives/players can read most CD media as well. Originally these were named as **"Digital Video Disc."** Since the technology became important to the computer world, the "video" was dropped, and it was dubbed as **"Digital Versatile Disc"** by the DVD Forum. **Read-Only Data DVDs - DVD-ROM** are designed for data files, a DVD-ROM disc is a higher-capacity CD-ROM. **Writable/Recordable Data DVDs - DVD-RAM** is a rewritable DVD that functions like a removable hard disk. It uses a phase-change technology like the CD-RW drives. DVD-RAM media can be rewritten 100,000 times before they are no longer usable. **Pen Drives** is a flash memory card that plugs into the

computer's USB port. Small enough to hook onto a keychain, it emulates a small disk drive and allows data to be easily transferred from one machine to another.

6. Keywords

Keywords of this lesson are Random and Sequential Storage devices, Storage Devices, Punched Paper Tape, Punched Cards, Paper, Magnetic Tape, Magnetic Drum, Floppy Diskette, Hard Disk Drive, Compact Disk, DVD, USB/Pen drives

7. Short answer type Questions

1. Differentiate between primary and secondary memory. Name some of the commonly used secondary devices
2. Differentiate between random access and sequential access devices.

8. Long answer type Questions

1. Describe the various storage devices.
2. Describe the different type of floppy disks.
3. Describe different types of hard disk drive.

9. Suggested Readings

- Information Technology by Satish Jain
- Information Technology and Management by Turban Mclean and Wetbrete
- Computer Fundamentals by Pradeep Kumar Sinha and Priti Sinha
- Fundamentals of Computers by V.Rajaraman, PHI, India

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Converted into SLM by: Dr. Vishal Singh

COMPUTER LANGUAGES

1. Objectives

Objectives of this lesson are to discuss the various types of Computer languages, their generations, Translators, Assemblers, Compilers and Interpreters.

2. Introduction

A language is nothing but a way of communication. We, human beings, use natural languages like Hindi, Punjabi, English, Urdu, Persian and Spanish etc. to communicate our

ideas and emotions with each other. Similarly we communicate with the computer in the language understood by the computer. The language understood by the computer is known as Computer language. The language, which the user employs to interact with the computer, is known as Programming or Computer Language. Computer needs to be given instructions to perform each task. The instructions are given in the form of computer programs. The process of giving instructions using computer languages is known as programming or coding.

3. Computer/Programming Languages

It is a language used to write instructions that can be translated into machine language and then executed by a computer. Programming Language consists of a set of characters, symbols and rules that allow the user to communicate with the computers. The words and symbols of a computer language must also be used as per set rules, which are known as the syntax rules of the language. In case of natural languages, people can make use of poor or incorrect vocabulary or grammar, and still it can be understood up to some extent. However in case of computer language, we must stick to the exact syntax rules of the language. Although computers can be programmed to understand many different computer languages, but strictly speaking computer can understand only one language and that is binary language, which consists of only 0s and 1s. Although these programs are easily understood by the computer, it proved too difficult for a normal human being to remember all the instructions in the form of 0s and 1s. Therefore, the computer remained a mystery to a common man until other languages such as assembly and especially high level languages were developed.

4. Source code

Programmers write programs in a form called source code. The source code consists of instructions in a particular language, like C or FORTRAN. The source code consists of the programming statements that are created by a programmer with a text editor or a visual programming tool and then saved in a file. For example, a programmer using the C language types in a desired sequence of C language statements using a text editor and then saves them as a named file. This file is said to contain the source code.

5. Object code

The compiler produces an intermediary form called object code. Object code is often the same as or similar to a computer's machine language. The object code file contains a sequence of instructions that the processor can understand but that is difficult for a human to read or modify. The object code is machine-dependent meaning that the compiled program can only be executed on a machine for which it has been compiled.

Source code and object code refer to the "before" and "after" versions of a compiled computer program. When we purchase or receive operating system or application software, it is usually in the form of compiled object code and the source code is not included. Proprietary software vendors usually don't allow us to try to improve their code. Now, there is a movement to develop software (Linux is an example) that is open to further improvements by anyone who wants to improve it, and here the source code is provided.

6. Classifications of Computer Languages

Over the years, programming languages have progressed from machine-oriented languages to problem oriented languages, which use common mathematical and/or English terms. However, computer languages are generally classified into the following categories.

- **Low level languages**
  - **Machine Language**
  - **Assembly Language**
- **High Level Languages**

6.1 Low level languages

Low level language is usually the most basic language, in which we directly communicate with hardware. Low-level languages are difficult to understand. Instructions written in low level languages are difficult to understand and modify. Machine and Assembly Languages are considered as Low Level Languages.

6.2 High Level Languages

High level languages are similar to English language and resemble human languages. We can write programs in English like manner. High level languages are much more convenient to use. These languages are designed to make programming easy. High level language code is easier to understand. Generally these are known as third-generation languages (3GL). Design of these programming languages is easier for a human to understand, including things like named variables, abstract data types and algebraic expression syntax. Examples of high level languages are BASIC, C, C++, C#, Delphi, Java, ALGOL, COBOL, FORTRAN and ADA etc.

Most of these languages have compilers and the advantage of this is speed. Independence is another factor as these languages are machine independent and could run on different machines. The advantages of high level languages include the support for ideas of abstraction so that programmers can concentrate on finding the solution to the problem rapidly, rather than on low-level details of data representation. The comparative ease of use and learning, improved portability and simplified debugging, modifications and maintenance led to reliability and lower software costs. New features are being added to make the language more powerful. Third generation languages often followed procedural code, meaning the language performs functions defined in specific procedures on how something is done.

Compiled and interpreted languages

High-level programming languages are generally divided for convenience into compiled languages and interpreted languages. Interpreted languages are read and then executed directly, with no compilation stage. Compiled languages are transformed into an executable form before running. However, there is rarely anything about a language that requires it to be exclusively compiled, or exclusively interpreted. The categorization usually reflects the most popular or widespread implementation of a language — for instance, BASIC is sometimes called an interpreted language and C a compiled one, despite the existence of BASIC compilers and C interpreters.

6.3 Machine Languages

As mentioned earlier that computer can understand only one language and that is binary language, which consists of only 0s and 1s. This language is called machine language. Machine language is the native language of computers. It uses only 0s and 1s to represent data and instructions. It is a most efficient in term of storage area use and execution speed and it also allows programmer to utilize the computer's full potential for processing data. In machine language everything is written as numbers. Programs written in machine language can be executed very fast by the computer. However writing a program in machine language has the following disadvantages:

1. **Machine dependent** – Programs written in a machine language are generally machine dependent. In order to transfer code to a different computer it needs to be completely rewritten since the machine language for one computer could be significantly different from another computer. Architectural considerations make portability difficult too. For example, the number of registers on one CPU architecture could differ from those of another.
2. **Difficult to learn and program –** It is difficult for the programmer either to memorize the several operation code numbers for the commands or to constantly refer to a reference card. Programmer is also forced to keep track of the storage locations of data and instructions.
3. **Error prone –** For writing programs in machine language, since a programmer has to remember the opcodes, and must keep track of the storage locations, it becomes very difficult to concentrate fully on the logic of the problem. This frequently results in programming errors.
4. **Difficult to modify –** It is difficult to modify machine language programs. Checking machine instructions to locate errors is very difficult and time consuming.

6.4 Assembly Languages

An assembly language is a low-level language. It implements a symbolic representation of the numeric machine codes and other constants. This representation is usually defined by the hardware manufacturer, and is based on abbreviations (called mnemonics) that help the programmer to remember individual instructions, registers, etc. A program written in assembly language consists of a series of instructions--mnemonics that correspond to a stream of executable instructions, when translated by an assembler that can be loaded into memory and executed. An assembly language is thus specific to a certain physical or virtual computer architecture (as opposed to most high-level languages, which are usually portable). Instructions (statements) in assembly language are generally very simple. Each instruction typically consists of an operation or opcode plus zero or more operands. Most instructions refer to a single value, or a pair of values. Generally, an opcode is a symbolic name for a single executable machine language instruction. Operands can be either immediate (typically one byte values, coded in the instruction itself) or the addresses of data located elsewhere in storage. Assembly languages eliminated much of the error-prone and time-consuming problems of machine language, freeing the programmer from tedious task of remembering

numeric codes and calculating addresses. They were once widely used for all sorts of programming. Today, assembly language is used primarily for direct hardware manipulation, access to specialized processor instructions, or to address critical performance issues. Typical uses are device drivers, low-level embedded systems, and real-time systems. Assembly language is used to write programs using the instruction set for a particular processor/controller. To write assembly code it is necessary to know the architecture of the processor or controller. Thus assembly language is not portable. Assembly language is more human-readable than machine language. Generally, statements in assembly language are written using short codes for the instruction and arguments, such as "MOV $12 SP", For example, an x86/IA-32 processor can execute the following binary instruction as expressed in machine language

- Binary: 10110000 01100001 (Hexadecimal: B0 61)

The equivalent assembly language representation is easier to remember

- MOV AL, 61h

This instruction means:

- Move the value 61h (or 97 decimal; the h-suffix means hexadecimal) into the processor register named "AL".

The mnemonic "mov" represents the opcode 1011 which moves the value in the second operand into the register indicated by the first operand.

7. Historical development of computer languages

Programming languages have evolved tremendously since early 1950's and this evolution has resulted in over hundreds of different languages being invented and used in the industry. This revolution was needed as we can now instruct computers more easily and faster than ever before due to technological advancement in hardware and software. Software for early computers was primarily written in assembly language for many years. The very limited memory capacity of early computers also created many technical problems. Development of computer languages has been divided into the following generations:

7.1 First Generation Languages

Programming language history really began with the work of Charles Babbage in the early nineteenth century who developed automated calculation for mathematical functions. A first-generation programming language was a machine-level programming language. Originally, no translator was used to compile or assemble the first-generation languages. Instructions were entered through the front panel switches of the computer system. The main benefit of first-generation programming languages was that the code a user writes can run very fast and efficiently, since it is directly executed by the CPU. However, machine language is somewhat more difficult to learn than higher generational programming languages and it is far more difficult to edit if errors occur. In addition, if instructions need to be added into memory at some location, then all the instructions after the insertion point need to be moved down to make room in memory to accommodate the new instructions. Doing so on a front panel with switches can be very difficult. Furthermore, portability was significantly reduced - in order to transfer

code to a different computer it needs to be completely rewritten since the machine language for one computer could be significantly different from another computer. Architectural considerations make portability difficult too. For example, the number of registers on one CPU architecture could differ from those of another. Though 1GL were typically used only with first generation computers, machine level programming still finds a use in several areas of modern programming.

Further developments in early 1950 brought us machine language without interpreters and compilers to translate languages. Micro-code is an example of the first generation language residing in the CPU written for doing multiplication or division. Computers then were programmed in binary notation that was very prone to errors. A simple algorithm resulted in lengthy code. This was then improved to mnemonic codes to represent operations.

7.2 Second Generation Languages

Symbolic assembly codes came in the mid 1950's, the second generation of programming language like AUTOCODER, SAP and SPS. Symbolic addresses allowed programmers to represent memory locations, variables and instructions with names. Programmers now had the flexibility not to change the addresses for new locations of variables whenever they are modified. Second-generation programming languages had the following properties:

- The code can be read and written by a programmer. To run on a computer it must be converted into a machine readable form, a process called assembly.
- The language was specific to a particular processor family and environment.

Second-generation languages are sometimes used in kernels and device drivers (though C is generally employed for this in modern kernels), but more often find use in extremely intensive processing such as games, video editing, graphic manipulation/rendering.

One method for creating such code is by allowing a compiler to generate a machine-optimized assembly language version of a particular function. This code is then hand-tuned, gaining both the brute-force insight of the machine optimizing algorithm and the intuitive abilities of the human optimizer.

This kind of programming is still considered fast and to program in machine language required high knowledge of the CPU and machine's instruction set. This also meant high hardware dependency and lack of portability.

7.3 Third generation Languages

Throughout the early 1960's till 1980 saw the emergence of the third generation programming languages. Languages like ALGOL 58, 60 and 68, COBOL, FORTRAN IV, ADA, BASIC, C, C++, C#, Delphi and Java are examples of this and were considered as high level languages. A third-generation language (3GL) is a programming language designed to be easier for a human to understand, including things like named variables, abstract data types, and algebraic expression syntax. Most 3GLs support structured programming. Most of these languages had compilers and the advantage of this was speed. Independence was another factor as these languages were machine independent and could run on different machines. The advantages of high level languages include the support for ideas of abstraction so that

programmers can concentrate on finding the solution to the problem rapidly, rather than on low-level details of data representation. The comparative ease of use and learning, improved portability and simplified debugging, modifications and maintenance led to reliability and lower software costs. Some languages were improved over time and some were influenced by previous languages, taking the desired features thought to be good and discarding unwanted ones. New features were also added to the desired features to make the language more powerful. Then, there were languages that evolved from other languages like LISP1 developed in 1959 for artificial intelligence work and had strong influences languages like MATHLAB, LPL and PL/I. Language like BALM had the combined influence of ALGOL-60 and LISP. These third generation languages are less processor dependent than lower level languages. An advantage in languages like C++ is that it gives the programmers a lot of control over how things are done in creating applications. This control however calls for more in depth knowledge of how the operating system and computer works. Many of the real programmers now still prefer to use these languages despite the fact the programmer having to devote a substantial professional effort to the leaning of a new complicated syntax which sometimes have little relation to human-language syntax even if it is in English. Third generation languages often followed procedural code, meaning the language performs functions defined in specific procedures on how something is done. A disadvantage with fourth generation languages was they were slow compared to compiled languages and they also lacked control. Programmers whose primary interests are programming and computing use third generation languages and programmers who use the computers and programs to solve problems from other applications are the main users of the fourth generation languages.

7.4 Fourth generation Languages

A fourth-generation programming language (1970s-1990) (abbreviated 4GL) is a programming language or programming environment designed with a specific purpose in mind, such as the development of commercial business software. Though used earlier in papers and discussions, the term 4GL was first used formally by James Martin in his book Applications Development Without Programmers in 1982 to refer to non-procedural, high-level specification languages. In the evolution of computing, the 4GL followed the 3GL in an upward trend toward higher abstraction and statement power. Features evident in fourth generation languages quite clearly are that it must be user friendly, portable and independent of operating systems, usable by non-programmers, having intelligent default options about what the user wants and allowing the user to obtain results fasts using minimum requirement code generated with bug-free code from high-level expressions (employing a data-base and dictionary management which makes applications easy and quick to change), which was not possible using COBOL or PL/I. Examples of this generation of languages are IBM's ADRS2, APL, CSP and AS, Power Builder, Access. 4GL and 5GL projects are more oriented toward problem solving and systems engineering. All 4GLs are designed to reduce programming effort, the time it takes to develop software, and the cost of software development. Just as the 3GL offered greater power to the programmer, so too did the 4GL open up the development environment to a wider population.

In terms of applications, a 4GL could be business oriented or it could deal with some technical domain.

One of the early (and portable) languages that had 4GL properties was Ramis developed by Gerald C. Cohen at Mathematica, a mathematical software company. Cohen left Mathematica and founded Information Builders to create a similar reporting-oriented 4GL, called Focus. Later 4GL types are tied to a database system and are far different from the earlier types in their use of techniques and resources that have resulted from the general improvement of computing with time. An interesting twist to the 4GL scene is realization that graphical interfaces and the related reasoning done by the user form a 'language' that is poorly understood. A disadvantage with fourth generation languages was they were slow compared to compiled languages and they also lacked control.

A number of different types of 4GLs exist:

- Table-driven (codeless) programming, usually running with runtime framework and libraries. Instead of using code, the developer defines his logic by selecting an operation in a pre-defined list of memory or data table manipulation commands. In other words, instead of coding, the developer uses Table-driven algorithm programming, a good example of this type of 4GL language is eDeveloper. These type of tool can be used for business application development usually consisting in a package allowing for both business data manipulation and reporting, therefore they come with GUI screens and report editors. They usually offer integration with lower level DLLs generated from a typical 3GL for when the need arise for more hardware/OS specific operations.
- Report generators take a description of the data format and the report to generate and from that they either generate the required report directly or they generate a program to generate the report.
- Similarly, forms generators manage online interactions with the application system users or generate programs to do so.
- More ambitious 4GLs (sometimes termed fourth generation environments) attempt to automatically generate whole systems from the outputs of CASE tools, specifications of screens and reports, and possibly also the specification of some additional processing logic.
- Data management 4GLs such as SAS, SPSS and Stata provide sophisticated coding commands for data manipulation, file reshaping, case selection and data documentation in the preparation of data for statistical analysis and reporting.

Some fourth-generation languages

General Use / Versatile

- DataFlex
- Forté TOOL (transactional object-oriented language)
- IBM VisualAgen/VisualAge Generator
- Panther

- PowerBuilder
- SheerPower4GL (Microsoft Windows Only)
- SQLWindows/Team Developer
- WinDev
- Up ! 5GL
- Visual DataFlex (Microsoft Windows Only)
- Discovery Machine Modeler

Database query languages

- FOCUS
- Genero
- SB+/SystemBuilder
- Informix-4GL
- NATURAL
- Progress 4GL
- SQL

Report generators

- BuildProfessional
- GEMBase
- IDL-PV/WAVE
- LINC
- Metafont
- NATURAL
- Oracle Reports
- Progress 4GL Query/Results
- Quest
- Report Builder
- RPG-II

Data manipulation, analysis, and reporting languages

- Ab Initio
- ABAP
- Aubit-4GL
- Audit Command Language
- Clarion Programming Language
- CorVision
- Culprit
- ADS/Online (plus transaction processing)
- DASL
- FOCUS

- GraphTalk
- IDL
- IGOR Pro
- Informix-4GL
- LANSA
- LabVIEW
- MAPPER (Unisys/Sperry) now part of BIS
- MARK-IV (Sterling/Informatics) now VISION:BUILDER of CA
- Mathematica
- MATLAB
- NATURAL
- Nomad
- PL/SQL
- Progress 4GL
- PROIV
- R
- Ramis
- S
- SAS
- SPSS
- Stata
- Synon
- XBase++
- SQR

Data-stream languages

- APE
- AVS
- Iris Explorer

Database driven GUI Application Development

- Genexus
- SB+/SystemBuilder
- Progress Dynamics
- UNIFACE

Screen painters and generators

- FOURGEN CASE Tools for Rapid Application Development by Gillani
- SB+/SystemBuilder
- Oracle Forms
- Progress 4GL ProVision

- Unify Accell

GUI creators

- 4th Dimension (Software)
- eDeveloper
- MATLAB's GUIDE
- Omnis Studio
- OpenROAD
- Progress 4GL AppBuilder
- Revolution programming language
- Sculptor 4GL

Web development languages

- Cold Fusion
- CSS

7.5 Fifth generation languages

The 1990's saw the developments of fifth generation languages like PROLOG, referring to systems used in the field of artificial intelligence, fuzzy logic and neural networks. A fifth-generation programming language (abbreviated 5GL) is a programming language based around solving problems using constraints given to the program, rather than using an algorithm written by a programmer. Most constraint-based and logic programming languages and some declarative languages are fifth-generation languages. This means computers can in the future have the ability to think for themselves and draw their own inferences using programmed information in large databases. Complex processes like understanding speech would appear to be trivial using these fast inferences and would make the software seem highly intelligent. In fact, these databases programmed in a specialized area of study would show a significant expertise greater than humans. Also, improvements in the fourth generation languages now carried features where users did not need any programming knowledge. Little or no coding and computer aided design with graphics provides an easy to use product that can generate new applications. This way, the programmer only needs to worry about what problems need to be solved and what conditions need to be met, without worrying about how to implement a routine or algorithm to solve them. Fifth-generation languages are used mainly in artificial intelligence research. Prolog, OPS5 and Mercury are the best known fifth-generation languages.

7.6 Sixth generation languages

What does the next generation of languages hold for us? The sixth generation? That is pretty uncertain at the moment. With fast processors, like in fifth generation computers, able to have multiple processors operating in parallel to solve problems simultaneously will probably ignite a whole new type of language being designed. The current trend of the Internet and the World Wide Web could cultivate a whole new breed of radical programmers for the future, now

exploring new boundaries with languages like HTML and Java. What happens next is entirely dependent on the future needs of the whole computer and communications industry.

8. Translators

As already mentioned, the only language that a computer can understand is the so called machine language. To convert Assembly language and high level language programs into machine language, we need translators. Normally for this purpose Assemblers, Interpreters and Compliers are used. To run a program of any particular language, we need the corresponding assembler, interpreter or compiler.

8.1 Assemblers

A utility program called an assembler is used to translate assembly language statements into the target computer's machine code. The assembler performs a more or less isomorphic translation (a one-to-one mapping) from mnemonic statements into machine instructions and data. Many sophisticated assemblers offer additional mechanisms to facilitate program development, control the assembly process and aid debugging. Modern assembler creates object code by translating assembly instruction mnemonics into op codes and by resolving symbolic names for memory locations and other entities. The use of symbolic references is a key feature of assemblers, saving tedious calculations and manual address updates after program modifications. More sophisticated high-level assemblers provide language abstractions such as:

- Advanced control structures
- High-level procedure/function declarations and invocations
- High-level abstract data types, including structures/records, unions, classes, and sets
- Sophisticated macro processing

Note that, in normal professional usage, the term assembler is often used ambiguously: It is frequently used to refer to an assembly language itself, rather than to the assembler utility.

8.2 Interpreters

An interpreter is a program which takes something written in a programming language and then runs it by executing a series of machine instructions, which are clearly defined for each word or token in the language. It is a program that implements or simulates a virtual machine using the base set of instructions of a programming language as its machine language. We can also think of an Interpreter as a program that implements a library containing the implementation of the basic instruction set of a programming language in machine language. An Interpreter reads the statements of a program, analyzes them and then executes them by calling the corresponding instructions of the library.

8.3 Compilers

A Compiler is a program that translates code of a programming language in machine code, also called object code. The object code can be executed directly on the machine where it was compiled. A compiler is a program which takes something written in a higher level language, usually called source code, and translates it into a lower level language, usually called object

code. It is a computer program (or set of programs) that translates text written in a computer language (the source code) into another computer language (the target language). Commonly the output has a form suitable for processing by other programs (e.g., a linker). The object code is machine-dependent meaning that the compiled program can only be executed on a machine for which it has been compiled. The most common reason to translate source code is to create an executable program. The name "compiler" is primarily used for programs that translate source code from a high-level programming language to a lower level language (e.g., assembly language or machine language). A program that translates from a low level language to a higher level one is a decompiler. A program that translates between high-level languages is usually called a language translator, source to source translator, or language converter. A compiler is likely to perform many or all of the operations like lexical analysis, preprocessing, parsing, semantic analysis, code generation etc.

One-pass versus multi-pass compilers

Classifying compilers by number of passes has its background in the hardware resource limitations of computers. Compiling involves performing lots of work and early computers did not have enough memory to contain one program that did all of this work. So compilers were split up into smaller programs which each made a pass over the source (or some representation of it) performing some of the required analysis and translations. The ability to compile in a single pass is often seen as a benefit because it simplifies the job of writing a compiler and one pass compilers are generally faster than multi-pass compilers. Many languages were designed so that they could be compiled in a single pass (e.g., Pascal).

9. Summary

A language is nothing but a way of communication. We, human beings, use natural languages like Hindi, Punjabi, English, Urdu, Persian and Spanish etc. to communicate our ideas and emotions with each other. Similarly we communicate with the computer in the language understood by the computer. The Programming Language consists of a set of characters, symbols and rules that allow the user to communicate with the computers. Source code and object code refer to the "before" and "after" versions of a compiled computer program. Low level language is the most basic language, in which we directly communicate with hardware. Low-level languages are difficult to understand. Machine and Assembly languages are considered to be low level languages. High level languages are similar to English language and resemble human languages. We can write programs in English like manner. Computer can understand only one language and that is binary language, which consists of only 0s and 1s. This language is called machine language. Main disadvantages of machine language are that it is machine dependent, difficult to learn, error prone and difficult to modify. Assembly language implements a symbolic representation of the numeric machine codes and other constants. Development of computer languages has been divided into different generations like First Generation Languages, Second Generation Languages, Third generation Languages, Fourth generation Languages, Fifth generation languages and Sixth generation languages. As computer can understand only one language, that is machine

language. To convert Assembly language and high level language programs into machine language, we need translators. Normally for this purpose Assemblers, Interpreters and Compliers are used. To run a program of any particular language, we need the corresponding assembler, interpreter or compiler. Assembler is used to translate assembly language statements into the target computer's machine code. An interpreter is a program which takes something written in a programming language and then runs it by executing a series of machine instructions, which are clearly defined for each word or token in the language A Compiler is a program that translates code of a programming language in machine code, also called object code. The object code can be executed directly on the machine where it was compiled.

10. Keywords

Keywords of this lesson are Computer/Programming Languages, Source code, Object code, Low level languages, High Level Languages, Machine Languages, Assembly Languages, First Generation Languages, Second Generation Languages, Third generation Languages, Fourth generation Languages, Fifth generation languages, Sixth generation languages, Translators, Assemblers, Interpreters and Compilers.

11. Short answer type Questions

1. Differentiate between Low level and high level languages.
2. Differentiate between Machine and Assembly languages.
3. Differentiate between Source and Object code.

12. Long answer type Questions

1. Describe different generations of computer languages.
2. Write short notes on Assembly languages
3. Write short notes on 4GL
4. Write short notes on Interpreters, Compilers and Assemblers

13. Suggested Readings

- Information Technology by Satish Jain
- Information Technology and Management by Turban Mclean and Wetbrete
- Computer Fundamentals by Pradeep Kumar Sinha and Priti Sinha
- Fundamentals of Computers by V.Rajaraman, PHI, India

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