

UNIT-I

FUNDAMENTALS OF COMPUTER

Fundamentals of Computer:- CPU, Basic logic gates, Computer Memory and Mass storage devices, Computer Hierarchy, Input Technologies, Output Technologies, Number Systems and Arithmetic: Decimal, Binary, Octal and Hexadecimal Number Systems, Binary Arithmetic.

WHAT IS COMPUTER?

A computer is an electronic device that can store, retrieve and process data at speed millions or billions times faster than a human.

Functionalities of a computer:

Any digital computer carries out five functions in gross terms:

- Takes data as input.
- Stores the data/instructions in its memory and use them when required.
- Processes the data and converts it into useful information.
- Generates the output
- Controls all the above four steps.

It can be used for various purposes, which is possible by using programs for different applications.

Program is set of instructions written in a particular sequence in computer related language.

CHARACTERISTICS OF COMPUTERS

Speed

Computer can perform millions (1,000,000) of instructions and even more per second. Therefore, we determine the speed of computer in terms of microsecond (10^{-6} part of a second) or nano-second (10^{-9} part of a second). From this you can imagine how fast your computer performs work.

Accuracy

In addition to speed, the computer should have accuracy or correctness in computing. The degree of accuracy of computer is very high and every calculation is performed with the same accuracy. The accuracy level is determined on the basis of design of computer. The errors in computer are due to human and inaccurate data.

Versatility

It means the capacity to perform completely different type of work. You may use your computer to prepare payroll slips. Next moment you may use it for inventory management or to prepare electric bills.

Power of Remembering

Computer has the power of storing any amount of information or data. Any information can be stored and recalled as long as you require it, for any numbers of years. It depends entirely upon you how much data you want to store in a computer and when to lose or retrieve these data.

No IQ

Computer is a dumb machine and it cannot do any work without instruction from the user. It performs the instructions at tremendous speed and with accuracy. It is you to decide what you want to do and in what sequence. So a computer cannot take its own decision as you can.

No Feeling

It does not have feelings or emotion, taste, knowledge and experience. Thus it does not get tired even after long hours of work. It does not distinguish between users.

Storage

The Computer has an in-built memory where it can store a large amount of data. You can also store data in secondary storage devices such as floppies, which can be kept outside your computer and can be carried to other computers.

ADVANTAGES

Following are the advantages of computers

1. High Speed:

- Computer is a very fast device. It is capable of performing calculation of very large amount of data.
- The computer has units of speed in microsecond, nanosecond, and even the picoseconds.
- It can perform millions of calculations in a few seconds as compared to man who will spend many months for doing the same task.

2. Accuracy:

- In addition to being very fast, computers are very accurate.
- The calculations are 100% error free. Computers perform all jobs with 100% accuracy provided that correct input has been given.

3. Storage Capability :

- Memory is a very important characteristic of computers.
- A computer has much more storage capacity than human beings.
- It can store large amount of data.
- It can store any type of data such as images, videos, text, audio and many others.

4. Reliability:

- A computer is a reliable machine.
- Modern electronic components have long lives.
- Computers are designed to make maintenance easy.

5. Automation:

- Computer is an automatic machine.
- Automation means ability to perform the given task automatically.
- Once a program is given to computer i.e. stored in computer memory, the program and instruction can control the program execution without human interaction.

6. Reduction in Paper Work:

- The use of computers for data processing in an organization leads to reduction in paper work and results in speeding up a process.
- As data in electronic files can be retrieved as and when required, the problem of maintenance of large number of paper files gets reduced.

7. Reduction in Cost

- Though the initial investment for installing a computer is high but it substantially reduces the cost of each of its transaction.

APPLICATIONS

Following list are the various applications of computers.

1. Business

A computer has high speed of calculation, diligence, accuracy, reliability, or versatility which made it an integrated part in all business organizations.

Computer is used in business organizations for:

- Payroll calculations
- Budgeting , Sales analysis , Financial forecasting
- Managing employees database
- Maintenance of stocks etc.

2. Banking:

- Today banking is almost totally dependent on computer.
- Banks provide following facilities:
- Banks provide online accounting facility, which includes current balances, deposits, overdrafts, interest charges, shares, and trustee records.
- ATM machines are making it even easier for customers to deal with banks.

3. Insurance:

Insurance companies are keeping all records up-to-date with the help of computers. The insurance companies, finance houses and stock broking firms are widely using computers for their concerns.

- Insurance companies are maintaining a database of all clients with information showing
- Procedure to continue with policies
- starting date of the policies
- next due installment of a policy
- maturity date
- interests due
- survival benefits , bonus

4. Education:

The computer has provided a lot of facilities in the education system.

- The computer provides a tool in the education system known as CBE (Computer Based Education).
- CBE involves control, delivery, and evaluation of learning.
- The computer education is rapidly increasing the graph of number of computer students.
- There are number of methods in which educational institutions can use computer to educate the students.
- It is used to prepare a database about performance of a student and analysis is carried out on this basis.

5. Marketing:

In marketing, uses of computer are following:

- Advertising - With computers, advertising professionals create art and graphics, write and revise copy, and print and disseminate ads with the goal of selling more products.
- At Home Shopping - Home shopping has been made possible through use of computerized catalogues that provide access to product information and permit direct entry of orders to be filled by the customers.

6. Health Care:

Computers have become important part in hospitals, labs, and dispensaries. The computers are being used in hospitals to keep the record of patients and medicines. It is also used in scanning and diagnosing different diseases. ECG, EEG, Ultrasounds and CT Scans etc. are also done by computerized machines.

Some major fields of health care in which computers are used are:

- Diagnostic System - Computers are used to collect data and identify cause of illness.
- Lab-diagnostic System - All tests can be done and reports are prepared by computer.
- Patient Monitoring System - These are used to check patient's signs for abnormality such as in Cardiac Arrest, ECG etc.
- Pharma Information System - Computer checks Drug-Labels, Expiry dates, harmful drug's side effects etc.
- Surgery: Nowadays, computers are also used in performing surgery.

7. Engineering Design:

Computers are widely used in engineering purpose.

One of major areas is CAD (Computer aided design).that provides creation and modification of images. Some fields are:

- Structural Engineering - Requires stress and strain analysis for design of Ships, Buildings, Budgets, and Airplanes etc.
- Industrial Engineering - Computers deal with design, implementation and improvement of integrated systems of people, materials and equipments.
- Architectural Engineering - Computers help in planning towns, designing buildings, determining a range of buildings on a site using both 2D and 3D drawings.

8. Military :

Computers are largely used in defense. Modern tanks, missiles, weapons etc. Military also employs computerized control systems. Some military areas where a computer has been used are:

- Missile Control
- Military Communication
- Military Operation and Planning
- Smart Weapons

9. Communication :

Communication means to convey a message, an idea, a picture or speech that is received and understood clearly and correctly by the person for whom it is meant for. Some main areas in this category are:

- E-mail , Chatting
- FTP
- Telnet
- Video-conferencing

10. Government :

Computers play an important role in government. Some major fields in this category are:

- Budgets
- Sales tax department
- Income tax department
- Male/Female ratio
- Computerization of voters lists
- Computerization of driving licensing system
- Computerization of PAN card
- Weather forecasting

COMPUTER TYPES

Computers can be broadly classified by their speed and computing power.

1. Personal Computers 2. Mini Computers 3. Mainframe Computers 4. Super Computers

1. PC (Personal Computer):

A PC can be defined as a small, relatively inexpensive computer designed for an individual user. PCs are based on the microprocessor technology that enables manufacturers to put an entire CPU on one chip. Businesses use personal computers for word processing, accounting, desktop publishing, and for running spreadsheet and database management applications. At home, the most popular use for personal computers is playing games and surfing Internet.

Although personal computers are designed as single-user systems, these systems are normally linked together to form a network. In terms of power, now-a-days High-end models of the Macintosh and PC offer the same computing power and graphics capability as low-end workstations by Sun Microsystems, Hewlett-Packard, and Dell.

2. Minicomputer :

It is a midsize multi-processing system capable of supporting up to 250 users simultaneously.

3. Mainframe :

Mainframe is very large in size and is an expensive computer capable of supporting hundreds or even thousands of users simultaneously. Mainframe executes many programs concurrently and supports much simultaneous execution of programs.

4. Supercomputer :

Supercomputers are one of the fastest computers currently available. Supercomputers are very expensive and are employed for specialized applications that require immense amount of mathematical calculations (number crunching). For example, weather forecasting, scientific simulations, (animated) graphics, fluid dynamic calculations, nuclear energy research, electronic design, and analysis of geological data (e.g. in petrochemical prospecting).

THE FIVE GENERATIONS OF COMPUTERS:

The history of computer development is often referred to in reference to the different generations of computing devices. Each generation of computer is characterized by a major technological development that fundamentally changed the way computers operate, resulting in increasingly smaller, cheaper, and more powerful and more efficient and reliable devices.

First Generation -1940-1956: Vacuum Tubes

The first computers used vacuum tubes for circuitry and magnetic drums for memory, and were often enormous, 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. Input was based on punched cards and paper tape, and output was displayed on printouts.

The UNIVAC and ENIAC computers are examples of first-generation computing devices. The UNIVAC was the first commercial computer delivered to a business client, the U.S. Census Bureau in 1951.

Second Generation -1956-1963: Transistors

Transistors replaced vacuum tubes 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. Though the transistor still generate a great deal of heat subjected the computer to damage, it was a vast improvement over the vacuum tube. Second-generation computers still relied on punched cards 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 their instructions in their memory, which moved from a magnetic drum to magnetic core technology.

Third Generation -1964-1971: Integrated Circuits

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.

Instead of punched cards and printouts, users interacted with third generation computers through keyboards and monitors and interfaced with an operating system, 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.

Fourth Generation -1971-Present: Microprocessors

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, developed in 1971, located all the components of the computer -from the central processing unit and memory to input/output controls -on a single chip.

In 1981 IBM introduced its first computer for the home user, and in 1984 Apple introduced the Macintosh. 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.

Fifth Generation -Present and Beyond: Artificial Intelligence

Fifth generation computing devices, based on artificial intelligence, 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 and are capable of learning and self-organization.

The elements of computer system fall into two major categories:

- **HARDWARE**
- **SOFTWARE**

COMPUTER HARDWARE

Hard ware is the equipment used to perform the necessary computations.

Basic Computer Hardware Components:

- Main memory
- Secondary memory, which includes storage devices such as hard disks , cds , dvd , flash drives
- Central Processing Unit (CPU)
- **Input Units :** Keyboard, Mouse, Scanner
- **Output Units:** Monitor, Printer, Plotter, Scanner, Modem, Speaker

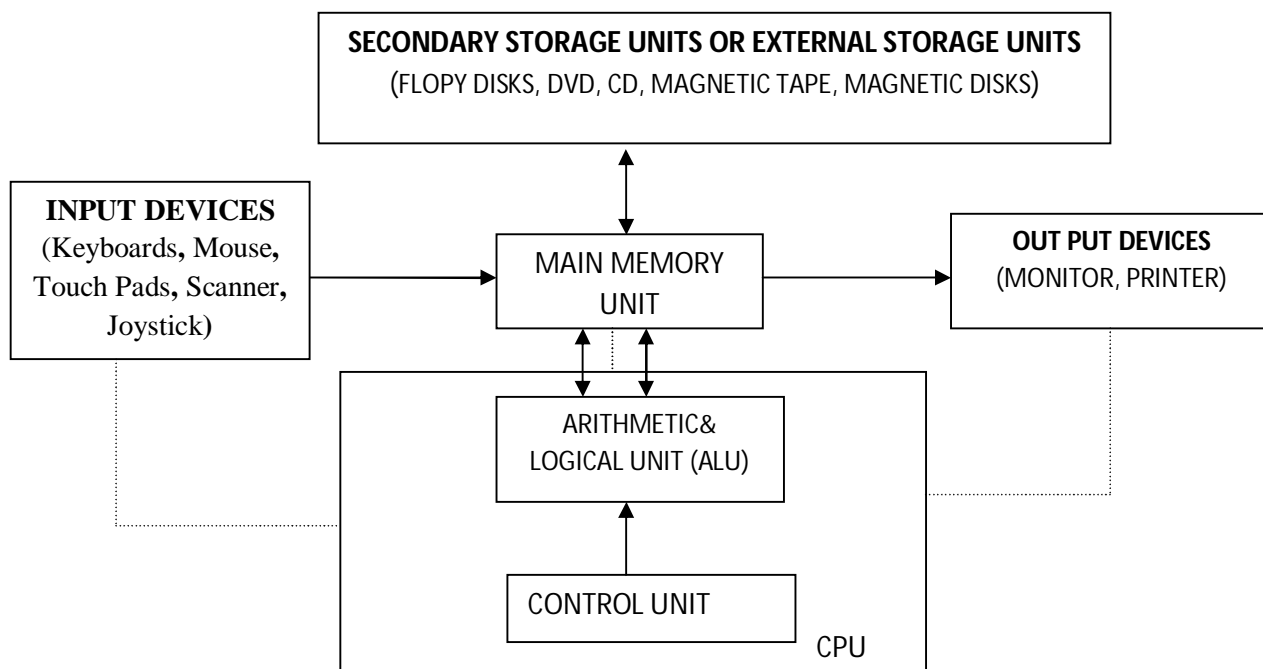


Fig: Block diagram for the hardware parts of a digital computer

The program must first be translated from secondary storage to main memory before it can be executed. Normally the person using a program (the program user) must supply data to be processed. These data are entered through an input device and can be accessed and manipulated by CPU. The results of this manipulation are then stored back in main memory.

Finally, the information in the main memory can be displayed through an output device.

MEMORY

It is an essential component in any computer. Consists of memory cells, which consist of ordered sequence of storage locations.

Address of a memory cell: the relative position of a memory cell in the computer's main memory.

Contents of a memory cell: The information stored in a memory cell, either a program instruction or data.

Bits and Bytes: Binary refers to a number system based on two numbers, 0 and 1, so a bit is either a 0 or a 1. Generally there are *eight bits to a byte*.

Storage and Retrieval of Information in Memory: A computer can either store a value into a memory in terms of binary number representations or retrieve a value from the memory.

Computers use two types of storage locations, one for storing the data that are being currently handled by CPU and the other for storing the results and future use. The storage location where the data are held temporarily is referred as the primary memory while the storage location where the program and data are stored permanently for future use is referred to as the secondary memory.

The data and instructions stored in the primary memory can be directly accessed by the CPU by using data and address buses. However the data stored in the secondary memory is not directly access by the CPU. First the data is transferred to primary memory and then to the CPU.

Memory of a computer is divided into two types

- 1) Primary Memory or Storage(or Main Memory)
- 2) Secondary Memory or Storage.

- **MAIN MEMORY:** Main memory stores programs, data and results. Most computers have two types of main memory.

Random-Access-Memory (RAM): Used for temporary storage of programs and data.

Everything in RAM will be lost when the computer is switch is off (i.e, volatile memory).

Read-Only-Memory (ROM): Used for permanently storage of programs and data. The computer can retrieve, but cannot store, information in ROM, hence its name, read-only. The data stored in ROM stay permanently even after the power is switched off and therefore ROM is a non-volatile memory. Start up instructions and critical instructions are burned into ROM chips at factory.

Types of ROM

(i) **Masked ROM:** Simply ROM is programmed with data as chip is fabricated. These chips are useful for consumer appliances, where large number of units are produced and once installed data will not be changed.

(ii) **PROM:** It's programmable ROM. Its contents are decided by the user. The user can store permanent programs, data etc in a PROM. The data is fed into it using a PROM programs.

(iii) **EPROM:** An EPROM is an erasable PROM. The stored data in EPROM's can be erased by exposing it to UV light for about 20 min. It's not easy to erase it because the EPROM IC has to be removed from the computer and exposed to UV light. The entire data is erased and not selected portions by the user. EPROM's are cheap and reliable.

(iv) **EEPROM (Electrically Erasable PROM):** The chip can be erased & reprogrammed on the board easily byte by byte. It can be erased within a few milliseconds. There is a limit on the number of times the EEPROM's can be reprogrammed, i.e.; usually around 10,000 times.

(v) **Flash Memory:** It's an electrically erasable & programmable permanent type memory. It uses one transistor memory all resulting in high packing density, low power consumption, lower cost & higher reliability. It's used in all power, digital cameras, MP3 players etc.

Types of RAM

(i) Dynamic RAM /DRAM

(ii) Static RAM/ SRAM

DRAM chips are like leaky capacitors. Initially data is stored in DRAM chip, charging its memory cells to their maximum value. The charge slowly leaks out and would eventually go too low to represent valid data. Before this happens a refresh circuitry reads the content of DRAM and rewrites the data, thus restoring memory cells to their maximum values.

DRAM is used to construct RAM in personal computers.

SRAM is more likely a register. Once data is written to SRAM it stays valid; it does not have to be refreshed.

SRAM is faster than DRAM but it is more expensive. The cache memory in personal computer is constructed from SRAM.

- **SECONDARY STORAGE DEVICES:** These devices are used to store huge amount of information. These are Hard disk, CDs, DVDs and flash memories.

Secondary Memory Characteristics:

- Connected to main memory.
- Used to hold programs and data.
- The content of secondary storage is easily changed.
- Used for long-term storage.
- Huge capacity compared to main memory, but access is slow.
- Usually data and programs are organized into files in secondary memory.

Hard Disk: Hard disks are attached to their disk drives and coated with a magnetic material. Each data bit is a magnetized spot on the disc, and the spots are arranged in concentric circles called tracks. The disc drive read/write head accesses data by moving across the spinning disk to the correct track and then sensing the spots as they move by. Hard discs hold from one to several hundred gigabytes (GB) of data, but clusters of hard drives that stores data from an entire network may provide as much as a terabyte (TB) of storage.

Optical Drives: For storing and retrieving data on compact discs (CDs) or digital versatile disks(DVDs) that can be removed from the drive. One CD can hold 680 MB of data. A DVD uses smaller pits packed in a tighter spiral, allowing storage of 4.7 GB of data one one layer. Some DVDs can hold four layers of data- two on each sidefor a total capacity of 17 GB, sufficient storage for as much as nine hours of studioquality video and multi-channel audio.

Flash Drive (USB) (Universal Serial Bus): Flash drives (stick memory) have no moving parts and all data transfer is by electronic signal only. Typical USB flash drives store 1 to a few GB of data, but 64 GB drives are also available.

Information stored on a disk is organized into separate collections called **files**: One file may contain a C program. Another file may contain the data to be processed by the program (a data file) or a file may contain a picture information. A file could contain results generated by a program (an output file). The names of all files stored on a disk are listed in the disk's **directory**. This directory may be divided into one or more levels of subdirectories or folders.

Terms used to quantify storage capacities:

Term	Abbreviation	Equivalent to	Comparison to Power of 10
Byte	B	8 Bits	
KiloByte	KB	1,024 (bytes)	$>10^{**3}$
MegaByte	MB	1,048,576(bytes)	$>10^{**6}$
GigaByte	GB	1,073,751,824(bytes)	$>10^{**9}$
TeraByte	TB	1,099,511,627,776(bytes)	$>10^{**12}$

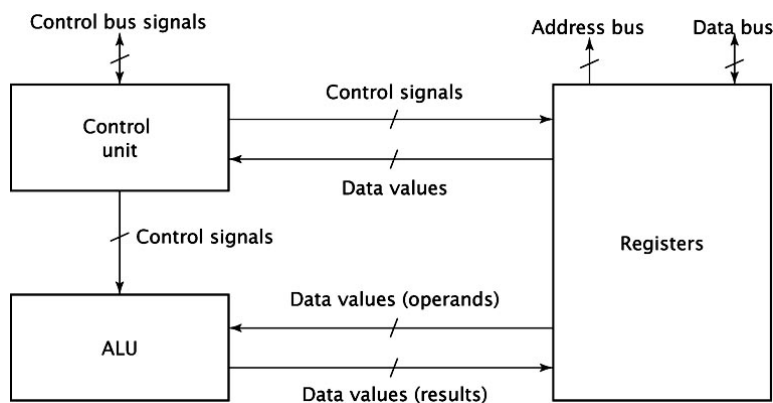
CENTRAL PROCESSING UNIT (CPU):

The Central Processing Unit (CPU) has two roles.

- A) Coordinating Operations of Computer
- B) Performing Arithmetic and Logical operations on data.

The CPU follows the instructions contained in a computer program to determine which operations should be carried out and in what order. The CPU fetches an instruction, interprets the instruction to determine what should be done and then retrieves any data needed to carry out that instruction. The CPU stores the results in main memory. The CPU can perform such arithmetic operations as addition, subtraction, multiplication, and division. The CPU can also compare the contents of two memory cells and make decision based on the result of that comparison.

A CPU's current instruction and data values are stored temporarily inside the CPU in special high-speed memory locations called **registers (high speed memory location)**.



Control Unit:

➤ This unit controls the operations of all parts of computer but does not carry out any actual data processing operations.

Functions of this unit are:

- It is responsible for controlling the transfer of data and instructions among other units of a computer.
- It manages and coordinates all the units of the computer.
- It obtains the instructions from the memory, interprets them, and directs the operation of the computer.
- It communicates with Input/output devices for transfer of data or results from storage.
- It does not process or store data.

ALU (Arithmetic Logic Unit)

➤ This unit consists of two subsections namely 1) Arithmetic section 2) Logic Section

Arithmetic Section

➤ Function of arithmetic section is to perform arithmetic operations like addition, subtraction, multiplication and division. All complex operations are done by making repetitive use of above operations.

Logic Section

➤ Function of logic section is to perform logic operations such as comparing, selecting, matching and merging of data.

REGISTERS:

CPU contains the following registers:

- Address register (AR) which supplies address to the memory.
- Program Counter (PC) which contains the address of next instruction to be executed.
- Data Register (DR) which receives instruction and data from memory.
- Instruction Register (IR) which stores the OP-code portion of the instruction code fetched from memory.

INPUT/OUTPUT DEVICES

We use Input/Output devices to communicate with the computer. They allow us to enter data for a computation and to observe the results of that computation.

Input Devices:

The following are input devices are used to give input to computer.

Keyboard: We use a *keyboard* as an input device to give input to computer.

A keyboard has keys for letters, numbers, and punctuation marks plus some extra keys for performing special functions.

Mouse: A *mouse* is an input device used to select elements on the screen, such as tools, icons and buttons, by pointing and clicking them. We can also use a mouse to draw and paint on the screen of the computer system.

Scanner: A *scanner* is an input device that converts documents and images as the digitized images understandable by the computer system.

Touch pad: A touch pad is a pointing device consisting of a soft pad sensitized to finger movement or pressure and used especially on laptop.

Trackball: A trackball is a stationary pointing device with a ball on its top or side. A trackball requires frequent cleaning because it picks up oils from fingers and dust from the environment. For users who have limited desk space, however, a trackball is a good alternative to a mouse because the device is stationary.

Joysticks: A joystick is a pointing device used for games or flight and driving simulations that is a vertical lever mounted on a base.

Touch screen: Touch-sensitive display device with which users interact by touching areas of the screen.

Magnetic stripe readers: A magnetic stripe reader, also called a magstripe reader, is a reading device that reads the magnetic stripe on the back of credit, entertainment, bank and other similar cards.

Microphones: A device that converts sound waves into analogous electrical waves.

OMR: Optical Mark Recognition (OMR) is a technology that reads hand-drawn marks such as small circles or rectangles. A person places these marks on a form, such as a test, survey, or questionnaire answer sheet.

Bar code readers: A bar code reader, also called a bar code scanner, is an optical reader that uses laser beams to read bar codes by using light patterns that pass through the bar code lines.

A bar code is an identification code that consists of a set of vertical lines and spaces of different widths. The bar code represents data that identifies the manufacturer and the item.

Web cams: A web cam is a video camera that displays its output on a Web page.. Some web sites use web cams to display still pictures that are updated at regular time intervals.

Light pens: A light pen is a hand held input device that can detect the presence of light. To select objects on the screen, a user presses the light pen against the surface of the screen or points the light pen at the screen and then presses a button on the pen. Light pens are ideal for areas where employees' hands might contain food, dirt, grease or other chemicals that could damage the computer.

OUTPUT DEVICES: These are used to pass on the processed data i.e., information through different mediums to the end users. The following are the output devices:

Monitor: It produces visual displays generated by the computer. The display device is used for visual presentation of textual and graphical information.

The Monitors are classified as cathode ray tube (CRT) monitors or liquid crystal display (LCD) monitors. The CRT monitors are large, occupy more space in the computer, whereas LCD monitors are thin, light weighted, and occupy lesser space.

CRT Monitor: A CRT monitor is a type of monitor that requires a cathode ray tube. A cathode-ray tube is a large, sealed glass tube. The front of the tube is the screen. Tiny dots of phosphor material coat the screen on a CRT. Each dot consists of a red, a green, and a blue phosphor. The three dots combine to make up each pixel. Inside the CRT, an electron beam moves back and forth across the back of the screen. This causes the dots on the front of the screen to glow, which produces an image on the screen.

TFT monitor: LCD monitors use a liquid compound to present information on a display device. TFT monitors are LCD monitors that use an active-matrix technology. The thin-film transistor (TFT) display, uses a separate transistor to apply charges to each liquid crystal cell and thus displays high-quality color that is viewable from all angles.

Multimedia Projectors: A device that takes the text and images displaying on a computer screen and projects them on a larger screen so an audience can see the image clearly.

Printer: It is an output device that transfers the text displayed on the screen, onto paper sheets (hard copy) that can be used by the end user. The various types of printers are dot matrix printers, inkjet printers and laser printers.

Laser printer: A laser printer is a high-speed, high-quality non impact printer. Laser printers are available in both black-and-white and color models. While laser printers usually cost more than ink-jet printers, they are also much faster.

Ink jet printer: An ink-jet printer is a type of non impact printer that forms characters and graphics by spraying tiny drops of liquid ink onto a piece of paper.

Dot matrix printer: A dot-matrix printer is an impact printer that produces printed images when tiny wire pins on a print head mechanism strike an inked ribbon. When the ribbon presses against the paper, it creates dots that form characters and graphics.

Plotter: It is also an output device connected to computer to print large documents, such as engineering or construction drawings. Plotters are classified into following:

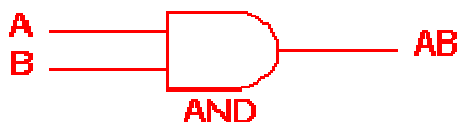
- Drum plotter
- Flat-bed plotter
- Inkjet plotter
- Electronic plotter

Speaker: It is an electromechanical device that converts an electrical signal into sound. This provides audio output.

LOGIC GATES

Digital systems are said to be constructed by using logic gates. These gates are the AND, OR, NOT, NAND, NOR, EXOR and EXNOR gates.

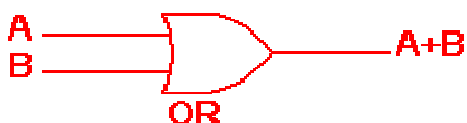
AND gate



2 Input AND gate		
A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

The AND gate is an electronic circuit that gives a **high** output (1) only if **all** its inputs are high. A dot (.) is used to show the AND operation i.e. A.B. This dot is sometimes omitted i.e. AB

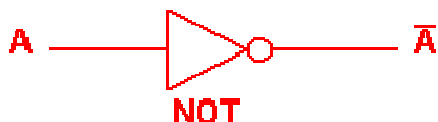
OR gate



2 Input OR gate		
A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

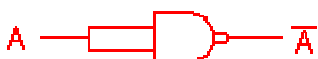
The OR gate is an electronic circuit that gives a high output (1) if **one or more** of its inputs are high. A plus (+) is used to show the OR operation.

NOT gate

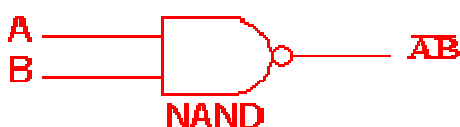


NOT gate	
A	Ā
0	1
1	0

The NOT gate is an electronic circuit that produces an inverted version of the input at its output. It is also known as an *inverter*. If the input variable is A, the inverted output is known as NOT A. This is also shown as A', or A with a bar over the top, as shown at the outputs. The diagrams below show two ways that the NAND logic gate can be configured to produce a NOT gate. It can also be done using NOR logic gates in the same way.



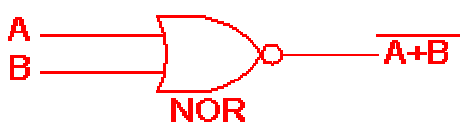
NAND gate



2 Input NAND gate		
A	B	A.B
0	0	1
0	1	1
1	0	1
1	1	0

This is a NOT-AND gate which is equal to an AND gate followed by a NOT gate. The outputs of all NAND gates are high if **any** of the inputs are low. The symbol is an AND gate with a small circle on the output. The small circle represents inversion.

NOR gate

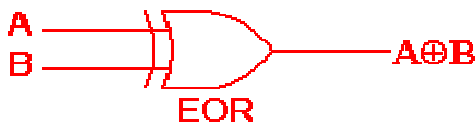


2 Input NOR gate		
A	B	A+B
0	0	1
0	1	0
1	0	0
1	1	0

This is a NOT-OR gate which is equal to an OR gate followed by a NOT gate. The outputs of all NOR gates are low if **any** of the inputs are high.

The symbol is an OR gate with a small circle on the output. The small circle represents inversion.

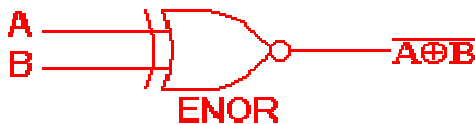
EXOR gate



A	B	$A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

The 'Exclusive-OR' gate is a circuit which will give a high output if **either, but not both**, of its two inputs are high. An encircled plus sign (\oplus) is used to show the EOR operation.

EXNOR gate



A	B	$\overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

The 'Exclusive-NOR' gate circuit does the opposite to the EOR gate. It will give a low output if **either, but not both**, of its two inputs are high. The symbol is an EXOR gate with a small circle on the output. The small circle represents inversion.

The NAND and NOR gates are called *universal functions* since with either one the AND and OR functions and NOT can be generated.

Note: A function in *sum of products* form can be implemented using NAND gates by replacing all AND and OR gates by NAND gates.

A function in *product of sums* form can be implemented using NOR gates by replacing all AND and OR gates by NOR gates.

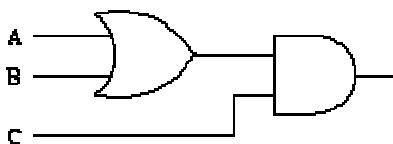
Logic gates representation using the Truth table

		INPUTS		OUTPUTS					
		A	B	AND	NAND	OR	NOR	EXOR	EXNOR
NOT gate									
A	\bar{A}	0	1	0	1	1	0	1	0
0	1	1	0	0	1	1	0	1	0
1	0	1	1	1	0	1	0	0	1

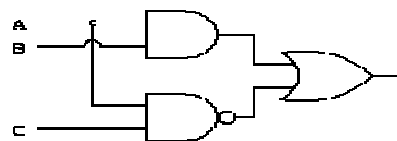
Example

Here are some logic gate circuit problems:

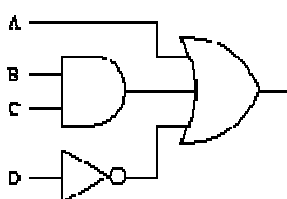
- Draw a logic circuit for $(A + B) C$.



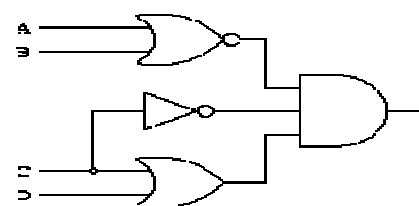
- Draw a logic circuit for $AB + \bar{A}C$.



- Draw a logic circuit for $A + BC + \bar{D}$.



- Draw a logic circuit for $\overline{(A + B)(C + D)C}$.



NUMBER SYSTEMS AND ARITHMETIC

Number System Basics

- Number systems, as we use them, consist of
 - a basic set Z of **digits** (or letters); example: $Z = \{0, 1, 2, \dots, 9\}$
 - a **base** $B = |Z|$ (how many digits); example: $B = |Z| = 10$
- A **number** is a linear sequence of digits.
- The **value of a digit** at a specific position depends on its "assigned meaning" and on its position.
- The **value of a number** N is the sum of these values.

Number: $N_B = d_{n-1}d_{n-2}\dots d_1d_0$ with word length n

$$\text{Value: } N_B = \sum_{i=0}^{n-1} d_i \cdot B^i = d_{n-1}B^{n-1} + d_{n-2}B^{n-2} + \dots + d_1B^1 + d_0B^0$$

Name	Base	Digits
dual binary	2	0, 1
octal	8	0, 1, 2, 3, 4, 5, 6, 7
decimal	10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
hexadecimal sedecimal	16	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

Decimal Number System

$$Z = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}; B = 10$$

- Each position to the **left** of a digit **increases** by a power of 10.
- Each position to the **right** of a digit **decreases** by a power of 10.

The system has a *base* or *radix* of ten. This means that each digit in a decimal number is multiplied by ten raised to a power corresponding to its position. Thus

$$847 = 8 * 10^2 + 4 * 10^1 + 7 * 10^0$$

Fractional values can be represented in the same way.

$$472.83 = 4 * 10^2 + 7 * 10^1 + 2 * 10^0 + 8 * 10^{-1} + 3 * 10^{-2}$$

Binary Number System

$$Z = \{0, 1\}; B = 2$$

- Each position to the **left** of a digit **increases** by a power of 2.
- Each position to the **right** of a digit **decreases** by a power of 2.

This means that it has a base of two. Each digit in a binary number is multiplied by two raised to a power corresponding to its position.

$$\begin{aligned} 1011 &= 1 * 2^3 + 0 * 2^2 + 1 * 2^1 + 1 * 2^0 \\ &= 1 * 8 + 0 * 4 + 1 * 2 + 1 = 11 \end{aligned}$$

Octal Number System

$$Z = \{0, 1, 2, 3, 4, 5, 6, 7\}; B = 8$$

- Each position to the **left** of a digit **increases** by a power of 8.
- Each position to the **right** of a digit **decreases** by a power of 8.

Example:

$$\begin{aligned} 12403_8 &= 1 * 8^4 + 2 * 8^3 + 4 * 8^2 + 0 * 8^1 + 3 * 8^0 \\ &= 1 * 4096 + 2 * 512 + 4 * 64 + 0 * 8 + 3 * 1 \\ &= 5379_{10} \end{aligned}$$

Hexadecimal Number System

$Z = \{0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F\}; B = 16$

- Each position to the **left** of a digit **increases** by a power of 16.
- Each position to the **right** of a digit **decreases** by a power of 16.

Example:

$$\begin{aligned} \text{FB40A}_{16} &= 15 \cdot 16^4 + 11 \cdot 16^3 + 4 \cdot 16^2 + 0 \cdot 16^1 + 10 \cdot 16^0 \\ &= 15 \cdot 65536 + 11 \cdot 4096 + 4 \cdot 256 + 0 \cdot 16 + 10 \cdot 1 \\ &= 1,029,130_{10} \end{aligned}$$

Comparison of Number Systems

Decimal	Dual	Octal	Hexadecimal	Decimal	Dual	Octal	Hexadecimal
0	00 000	0 0	0 0	16	10 000	2 0	1 0
1	00 001	0 1	0 1	17	10 001	2 1	1 1
2	00 010	0 2	0 2	18	10 010	2 2	1 2
3	00 011	0 3	0 3	19	10 011	2 3	1 3
4	00 100	0 4	0 4	20	10 100	2 4	1 4
5	00 101	0 5	0 5	21	10 101	2 5	1 5
6	00 110	0 6	0 6	22	10 110	2 6	1 6
7	00 111	0 7	0 7	23	10 111	2 7	1 7
8	01 000	1 0	0 8	24	11 000	3 0	1 8
9	01 001	1 1	0 9	25	11 001	3 1	1 9
10	01 010	1 2	0 A	26	11 010	3 2	1 A
11	01 011	1 3	0 B	27	11 011	3 3	1 B
12	01 100	1 4	0 C	28	11 100	3 4	1 C
13	01 101	1 5	0 D	29	11 101	3 5	1 D
14	01 110	1 6	0 E	30	11 110	3 6	1 E
15	01 111	1 7	0 F	31	11 111	3 7	1 F

Conversions between Number Systems

Conversion of Natural Numbers

Base 10 \Rightarrow Base B Conversion

We use the method of **iterated division** to convert a number N_{10} of base 10 into a number N_B of base B .

1. Divide the number N_{10} by B : whole number \bar{N} & remainder R .
 - Take \bar{N} as the next number to be divided by B .
 - Keep R as the next left-most digit of the new number N_B .
2. If \bar{N} is zero then STOP, else set $N_{10} = \bar{N}$ and go to step 1.

Conversion of Rational Numbers

Note: An exact conversion of rational numbers $R_{10} \Rightarrow R_B$ or $R_B \Rightarrow R_{10}$ is not always possible.

- We want: $R_{10} = R_B + \varepsilon$, where ε is a "sufficiently" small number.

Base B \rightarrow Base 10 Conversion

Example: $0.11001_2 = ?_{10}$

$$\begin{aligned} 0.11001 &= 1 \cdot 2^{-1} + 1 \cdot 2^{-2} + 0 \cdot 2^{-3} + 0 \cdot 2^{-4} + 1 \cdot 2^{-5} \\ &= 1 \cdot 0.5 + 1 \cdot 0.25 + 0 \cdot 0.125 + 0 \cdot 0.0625 + 1 \cdot 0.03125 \\ &= 0.5 + 0.25 + 0.03125 \\ &= 0.78125_{10} \end{aligned}$$

Binary-to-Decimal Conversion:

The conversion process is straight forward and is done as follows: Multiply binary digit (1 or 0) in each position by the weight of the position and add the results. The following examples explain the process.

Example 1:

Convert the following binary number to their decimal equivalent. (a) 1101 (b) 1001

Solution:

$$\begin{aligned} \text{(a)} \quad 1101 &= (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) \\ &= 8 + 4 + 0 + 1 = 13 \\ \text{(b)} \quad 1001 &= (1 \times 2^3) + (0 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) \\ &= 8 + 0 + 0 + 1 = 9 \end{aligned}$$

Example 2:

Convert the following binary numbers to their decimal equivalent. (a) 0.011 (b) 0.111

Solution:

$$\begin{aligned} \text{(a)} \quad 0.011 &= (0 \times 2^{-1}) + (1 \times 2^{-2}) + (1 \times 2^{-3}) \\ &= 0 + \frac{1}{4} + \frac{1}{8} \\ &= 0.25 + 0.125 = 0.375 \\ \text{(b)} \quad 0.111 &= (1 \times 2^{-1}) + (1 \times 2^{-2}) + (1 \times 2^{-3}) \\ &= \frac{1}{2} + \frac{1}{4} + \frac{1}{8} \\ &= 0.5 + 0.25 + 0.125 = 0.875 \end{aligned}$$

Example 3: Convert the binary number 110.011 to its decimal equivalent.

Solution:

$$\begin{aligned} 110.011 &= (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) + (0 \times 2^{-1}) \\ &\quad + (1 \times 2^{-2}) + (1 \times 2^{-3}) \\ &= 4 + 2 + 0 + 0 + \frac{1}{4} + \frac{1}{8} \\ &= 4 + 2 + 0.25 + 0.125 = 6.375 \end{aligned}$$

Decimal-to-Binary Conversion:

It is frequently necessary to convert decimal numbers to equivalent binary numbers. The two most frequently used methods for making the conversion are the Repeated division-by-2 or multiplication-by-2 method.

Repeated Division-by-2 Or Multiplication-by-2 Method:

To convert a decimal whole number to an equivalent number in a new base, the decimal number is repeatedly divided by the new base.

Repeated division by 2 means that the original number is divided by 2, the resulting quotient is divided by 2, and each resulting quotient thereafter is divided by 2 until the quotient is 0. The remainder resulting from each division forms binary number. The first remainder to be produced is called the least significant bit (LSB) and the last remainder is called most significant bit (MSB).

When converting decimal fraction to binary, multiply repeatedly by 2 any fractional part. The equivalent binary number is formed from the 1 or 0 in the units position.

Example 4: Convert the decimal number 17 to binary.

Solution:

2	17	
2	8 - 1	→ L.S.B.
2	4 - 0	
2	2 - 0	
2	1 - 0	
	0 - 1	→ M.S.B.

Therefore, $17 = 10001$

Example 5: Convert the decimal number 0.625 to binary.

Solution:

$0.625 \times 2 = 1.250$	1 (M S B)
$0.250 \times 2 = 0.500$	0
$0.25 \times 2 = 1.00$	1 (L S B)

Therefore, $0.625 = 0.101$

Octal-to-Decimal Conversion:

Octal numbers are converted to their decimal equivalent by multiplying the weight of each position by the digit in that position and adding the products.

Convert the following octal numbers to their decimal, equivalent. (a) 35_8 (b) 100_8 (c) 0.24_8

$$\begin{aligned} \text{(a)} \quad 35_8 &= (3 \times 8^1) + (5 \times 8^0) \\ &= 24 + 5 = 29 \end{aligned}$$

$$\begin{aligned} \text{(a)} \quad 100_8 &= (1 \times 8^2) + (0 \times 8^1) + (0 \times 8^0) \\ &= 64 + 0 + 0 = 64_{10} \end{aligned}$$

$$\begin{aligned} \text{(b)} \quad 0.24_8 &= (2 \times 8^{-1}) + (4 \times 8^{-2}) \\ &= \frac{2}{8} + \frac{4}{64} \\ &= 0.3125_{10} \end{aligned}$$

Decimal-to-Octal Conversion:

To convert decimal numbers to their octal equivalent, the following procedures are employed:

- Whole-number conversion: Repeated division-by-8.
- Fractional number conversion: Repeated multiplication-by-8.

Repeated Division-by-8 Method:

The repeated-division by 8 method of converting decimal to octal applies only to whole numbers.

Convert the following decimal numbers to their octal equivalent: (a) 245 (b) 175

Solution:

8	245	8	175
8	30 – 5 (LSD)	8	21 – 7
8	3 6	8	2 5
	0 – 6 (MSD)		0 – 2

Therefore, $245_{10} = 365_8$, therefore, $175_{10} = 257_8$

Repeated Multiplication-by-8 Method:

To convert decimal fractions to their Octal equivalent requires repeated Multiplication by 8, as shown in the following example.

Convert the decimal fraction 0.432 to octal equivalent.

Solution:

		Carry
0.432×8	$= 3.456$	3(MSD)
0.456×8	$= 3.648$	3
0.648×8	$= 5.184$	5
0.184×8	$= 1.472$	1 (LSD)

The first carry is nearest the octal point, therefore,

$$0.432_{10} = 0.3351_8$$

The conversion to octal is not precise, since there is a remainder. If greater accuracy is required, we simply continue multiplying by 8 to obtain more octal digits.

Octal-to-Binary-Conversion:

The primary reason for our interest in octal numbers lies in entering and outputting computer data and because of the ease of octal-to-binary conversion. Computers recognize only binary information and may be programmed using only, 1's and 0's. Converting numbers from octal to binary can be done essentially by inspection. Since there are eight symbols used for counting in the octal system and eight combinations of three binary digits that corresponds to these single-digit octal numbers, we can assign a binary three-digit combination to each single-digit octal number.

Octal and Binary Number Correspondence.

Octal	Binary
0	0 0 0
1	1 0 1
2	0 1 0
3	0 1 1
4	1 0 0
5	1 0 1
6	1 1 0
7	1 1 1

Convert the following octal numbers to their binary equivalent. (a) 247_8 (b) 501_8

	(a)	2	4	7	Octal
		010	100	111	binary
Thus,		$247_8 = 010100111_2$			
	(b)	5	0	1	octal
		101	000	001	binary
Thus,		$501_8 = 101000001_2$			

Binary-to-Octal Conversion:

In printing out octal numbers, the modern electronic digital computer performs a binary-to-octal conversion. This is a simple procedure. The binary number is divided into groups to three bits, counting to the right and to the left from the binary point and then each group of three is interpreted as an octal digit;

Example 11: Convert 11010101.01101 to an octal-number.

Solution: $011\ 010\ 101\ .\ 011\ 10$
 $\underline{011}\ \underline{010}\ \underline{101}\ \underline{011}\ \underline{010}$
 $3\ 2\ 5\ 3\ 2$

Therefore $11010101.01101_2 = 325.32_8$

Converting from Decimal to Hexadecimal

The method is similar to converting a decimal to a binary and involves dividing the number by decimal 16 and noting the remainders. The *first* remainder is the least significant digit and the *last* remainder is the most significant digit.

For example,

$4620_{(base\ 10)} = 120C_{(base\ 16)}$	$4620 \div 16 = 288$	remainder	12 = C	LSB
	$288 \div 16 = 18$	remainder	0	
	$18 \div 16 = 1$	remainder	2	
	$1 \div 16 = 0$	remainder	1	MSB

Converting between Binary and Hexadecimal

From Binary to Hexadecimal: To convert a binary number into its hexadecimal form, start by grouping the digits into 4-bit groups. Beginning with the least significant bit (all the way to the right of the number), write the hexadecimal equivalent of each group.

For example,

$1001111101100101_{(base\ 2)} = 9F65_{(base\ 16)}$	$1001\ 1111\ 0110\ 0101\ (base\ 2)$ <hr style="width: 100%; border: 0.5px solid black;"/> $9\ F\ 6\ 5\ (base\ 16)$ MSB LSB
--	---

From Hexadecimal to Binary: To convert a hexadecimal number into a binary, just reverse the above process; starting all the way to the right, convert each digit into a 4-bit binary number.

BINARY ARITHMETIC

Elementary Rules for addition, subtraction, and multiplication

	Operation	Result	Carry
Addition	0 + 0	0	0
	0 + 1	1	0
	1 + 0	1	0
	1 + 1	0	1
Subtraction	0 - 0	0	0
	0 - 1	1	1
	1 - 0	1	0
	1 - 1	0	0
Multiplication	0 · 0	0	0
	0 · 1	0	0
	1 · 0	0	0
	1 · 1	1	0

Binary Addition:

Binary addition is performed in the same way as addition in the decimal-system. Binary addition obeys the following four basic rules:

$$\begin{array}{r} 0 \\ + 0 \\ \hline 0 \end{array} \quad \begin{array}{r} 0 \\ + 1 \\ \hline 1 \end{array} \quad \begin{array}{r} 1 \\ + 0 \\ \hline 1 \end{array} \quad \begin{array}{r} 1 \\ + 1 \\ \hline 10 \end{array}$$

The last rule states that

binary one + binary one = binary two = binary "one zero"

When adding more than single-digit binary number, carry into, higher order columns as is done when adding decimal numbers.

Example: Add (a) 111 and 101

$$\begin{array}{r} \textcircled{1} \textcircled{1} \\ 111 \\ 101 \\ \hline 1100 \end{array}$$

Binary Subtraction:

Binary subtraction is just as simple as addition subtraction of one bit from another obey the following four basic rules

$$0 - 0 = 0$$

$$1 - 1 = 0$$

$$1 - 0 = 1$$

$$10 - 1 = 1 \text{ with a transfer (borrow) of 1.}$$

When doing subtracting, it is sometimes necessary to borrow from the next higher-order column. The only it will be necessary to borrow is when we try to subtract a 1 from a 0. In this case a 1 is borrowed from the next higher-order column, which leaves a 0 in that column and creates a 10 i.e., 2 in the column being subtracted.

Example: Perform the following subtractions. (a) 11 - 01, (b) 11-10 (c) 100 - 011

$$\begin{array}{r} \text{(a)} \quad 11 \\ - 01 \\ \hline 10 \end{array} \quad \begin{array}{r} \text{(b)} \quad 11 \\ - 10 \\ \hline 01 \end{array} \quad \begin{array}{r} \text{(c)} \quad 100 \\ - 011 \\ \hline 001 \end{array}$$

When subtracting a larger number from a smaller number, the results will be negative. To perform this subtraction, one must subtract the smaller number from the larger and prefix the results with the sign of the larger number.

Example: Perform the following subtraction 101 – 111.

Subtract the smaller number from the larger.

$$\begin{array}{r} 111 \\ - 101 \\ \hline 010 \end{array}$$

Thus $101 - 111 = -010 = -10$

Binary multiplication:

Binary multiplication is performed in the same manner as decimal multiplication. It is much easier, since there are only two possible results of multiplying two bits. The Binary multiplication obeys the four basic rules.

$$0 \times 0 = 0$$

$$0 \times 1 = 0$$

$$1 \times 0 = 0$$

$$1 \times 1 = 1$$

Example : Multiply the following binary numbers.

(a) 101 X 11 (b) 1101 X 10

(c) 1010 X 101 (d) 1011 X 1010

Solution:

$$(a) \begin{array}{r} 101 \\ \underline{11} \times \\ 101 \\ \underline{101} \\ 1111 \end{array}$$

$$(b) \begin{array}{r} 11101 \\ \underline{10} \times \\ 0000 \\ \underline{1101} \\ 11010 \end{array}$$

$$(c) \begin{array}{r} 1010 \\ \underline{101} \times \\ 1010 \\ 0000 \\ \underline{1010} \\ 110010 \end{array}$$

$$(d) \begin{array}{r} 1011 \\ \underline{1010} \times \\ 0000 \\ 1011 \times \\ 0000 \times \\ \underline{1011 \times} \\ 1101110 \end{array}$$

Multiplication of fractional number is performed in the same way as with fractional numbers in the decimal numbers.

Example : Perform the binary multiplication 0.01 X 11.

$$\begin{array}{r} 0.01 \\ \underline{11} \times \\ 01 \\ \underline{01 \times} \\ 0.11 \end{array}$$

Binary Division:

Division in the binary number system employees the same procedure as division in the decimal system;

Example: Perform the following binary division. (a) $110 \div 11$ (b) $1100 \div 11$

Solution:

(a)	$\begin{array}{r} 10 \\ 11 \overline{) 110} \\ \underline{11} \\ 00 \\ \underline{00} \\ 00 \end{array}$	(b)	$\begin{array}{r} 100 \\ 11 \overline{) 11000} \\ \underline{11} \\ 00 \\ \underline{00} \\ 00 \\ \underline{00} \\ 00 \end{array}$
-----	--	-----	--

Binary division problems with remainders are also treated the same as in the decimal system, as illustrates the following example.

Example : Perform the following binary division: (a) $1111 \div 110$ (b) $1100 \div 101$

Solution:

(a)	$\begin{array}{r} 10.1 \\ 110 \overline{) 1111.00} \\ \underline{110} \\ 110 \\ \underline{110} \\ 000 \end{array}$	(b)	$\begin{array}{r} 10.011 \\ 110 \overline{) 1100.00} \\ \underline{101} \\ 100 \\ \underline{000} \\ 1000 \\ 101 \\ 110 \\ \underline{ 101} \\ 1 \\ \text{(remainder)} \end{array}$
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EXERCISE

Q.1: Convert the following binary numbers to decimal equivalent.

- (a) 100 (b) 11010 (c) 10110010 (d) 1.001
 (e) 110100.010011 (f) 11010.10110 (g) 1000001.111

Q.2: Convert the following decimal numbers to binary equivalent.

- (a) 16 (b) 247 (c) 962.84 (d) 0.0132
 (e) 6.71

Q.3: Convert the following octal numbers to their decimal equivalent:

- (a) 14_8 (b) 236_8 (c) 1432_8 (d) 0.43_8
 (e) 0.254_8 (f) $(16742.3)_8$ (g) $(206.104)_8$

Q.4: Convert the following decimals numbers to their octal equivalent:

- (a) 29 (b) 68 (c) 125 (d) 243.67
 (e) 419.95 (f) 645.7 (g) 39.4475 (h) 49.21875

Q.5: Convert the following octal numbers to their binary equivalent:

- (a) 13_8 (b) 27_8 (c) 65_8 (d) 124.375_8
 (e) 217.436_8

Q.6: Convert the following binary numbers to their octal equivalent:

- (a) 10110010 (b) 10101101
 (c) 1110101 (d) 10111.101
 (e) 111010.001

Q.7: Convert 18×24 to binary form and then perform binary multiplication.

Q.8: Convert $58.75 \div 23.5$ to binary form and then perform operation.

Q.9: Add the following binary numbers:

- (a)
$$\begin{array}{r} 11 \\ + 11 \\ \hline \end{array}$$
 (b)
$$\begin{array}{r} 1011 \\ + 1101 \\ \hline \end{array}$$
- (c)
$$\begin{array}{r} 101011 \\ + 110101 \\ \hline \end{array}$$
 (d)
$$\begin{array}{r} 1110101 \\ + 1011111 \\ \hline \end{array}$$

Q.10: Add the following binary numbers:

- (a)
$$\begin{array}{r} 1011 \\ + 1101 \\ \hline 1011 \\ \hline \end{array}$$
 (b)
$$\begin{array}{r} 1010110 \\ 1110101 \\ + 1001010 \\ \hline \end{array}$$
- (c)
$$\begin{array}{r} 1010110 \\ 1111011 \\ + 1011111 \\ \hline \end{array}$$
 (d)
$$\begin{array}{r} 10110110 \\ 11010101 \\ + 11010110 \\ \hline \end{array}$$

Q.11: Subtract the following binary numbers:

- (a)
$$\begin{array}{r} 11 \\ - 10 \\ \hline \end{array}$$
 (b)
$$\begin{array}{r} 111 \\ - 101 \\ \hline \end{array}$$
- (c)
$$\begin{array}{r} 101011 \\ - 100101 \\ \hline \end{array}$$
 (d)
$$\begin{array}{r} 11100001 \\ - 10011110 \\ \hline \end{array}$$

Q.12: Multiply the following binary numbers:

- (a) 11×11 (b) 101×10 (c) 110×101
 (d) 1011×1101 (e) 1010×101

Q.13: Divide the following binary numbers:

- (a) $110 \div 10$ (b) $10110 \div 10$
 (d) $101101 \div 1.1$ (e) $11001.11 \div 1101$

Answers

- Q.1:** (a) 4 (b) 26 (c) 178 (d) 1.125
 (e) 52.2969 (f) 26.6875 (g) 65.875
- Q.2:** (a) 10000_2 (b) 11110111_2 (c) 1111000010.11010111_2
 (d) 0.000000110110_2 (e) 110.1011110_2
- Q.3:** (a) 12 (b) 158 (c) 794 (d) 0.5469
 (e) 0.3359 (f) 7650.375 (g) 134.1328
- Q.4:** (a) 35_8 (b) 104_8 (c) 175_8 (d) 363.527_8
 (e) 643.2631_8 (f) $(1205.043)_8$ (g) 47.345_8
 (h) 61.61_8
- Q.5:** (a) 001011 (b) 010111 (c) 110101
 (d) 001010100.011111101 (e) 010001111.100011110
- Q.6:** (a) 262_8 (b) 255_8 (c) 165_8 (d) 27.5_8 (e) 72.1_8
- Q.7:** 110110000_2
- Q.8:** 10.1_2
- Q.9:** (a) 110 (b) 11000 (c) 1100000 (d) 11010100
- Q.10:** (a) 100011 (b) 100010101 (c) 100110000
 (d) 1001100001
- Q.11:** (a) 01 (b) 10 (c) 110 (d) 1000011
- Q.12:** (a) 1001 (b) 1100 (c) 11110 (d) 110010
 (e) 10001111
- Q.13:** (a) 11 (b) 1011 (c) 01.111111 (d) 11110