Southern Technical University
ThiQar Technical College

Electromechanical Systems Techniques Engineering Department

First Year

Computer Science

Assist Lect. Ahmed A.J Al-Hchiami
M.Tech of CNIS
CCNA, MCSA, C, C++, JAVA, VB.NET, VB.6, Oracle

Lecture - 1

Computer Hardware and Software Concepts

Introduction

A basic computer system is defined as a device that accepts input, processes data, stores data, and produces output. A personal computer system includes a computer, peripheral devices, and software. Computers are categorized into five general types, based mainly on their processing speeds, size, and their capacity to store data: *supercomputers, mainframe computers, minicomputers, microcomputers*, and *microcontrollers*.

Computer Hardware

Computer **hardware** refers to the physical components of a computer system. Hardware appears both inside and outside the computer. **Peripheral devices** are equipment used with a computer to enhance its functionality. They are devices that are "outside" of or in addition to, the computer (i.e. printer, scanner, and modem). The following diagram displays the hardware devices found on most personal computer systems

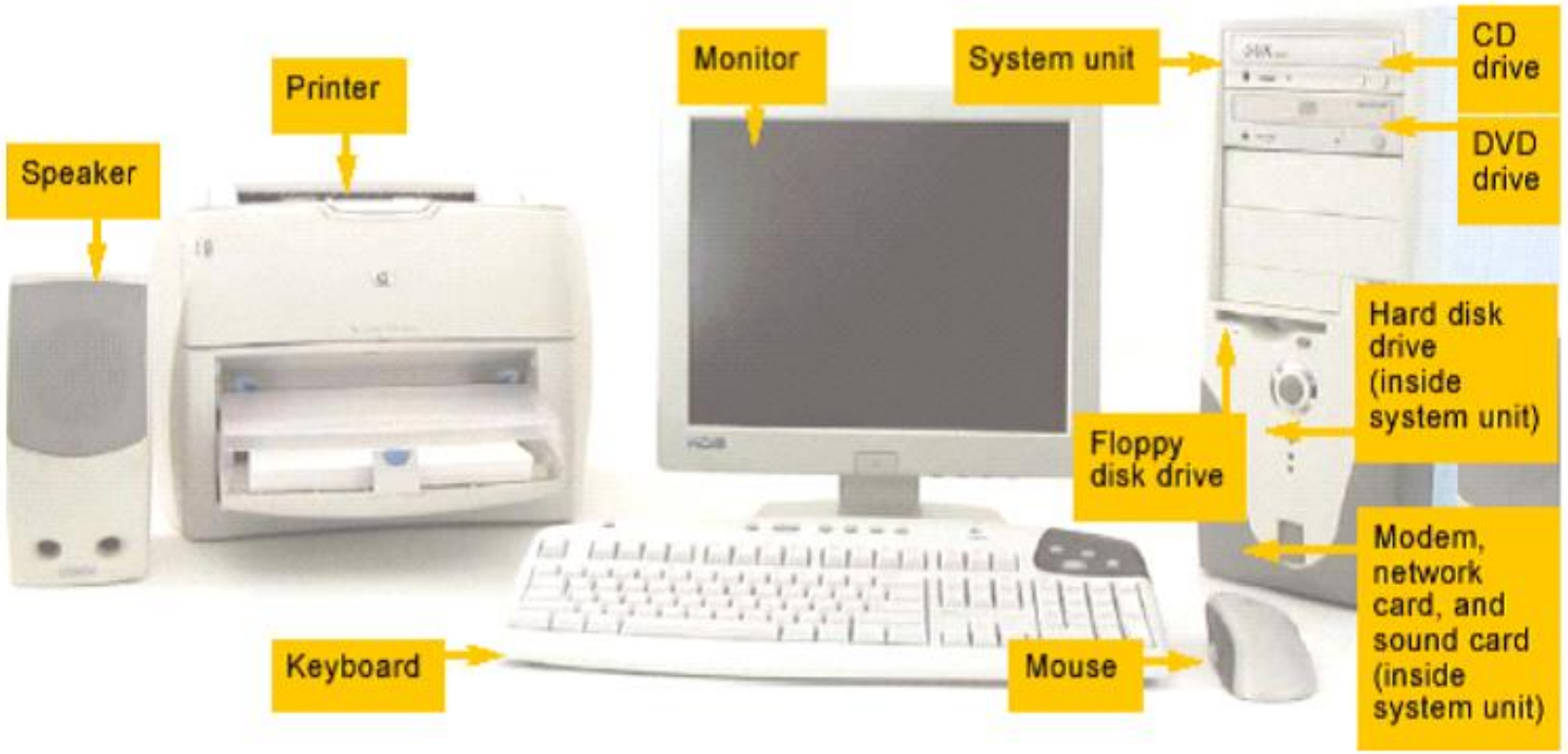


Figure (1): Hardware Devices

In general, a computer system is comprised of input devices, a central processing unit (CPU), output devices, and memory. The computer system component is shown in figure (2). The relationship between different components of computer systems is shown. Arrows indicate the basic movement of data or instruction among these elements.

The basic input devices are keyboard, mouse, and the scanner. The basic output devices are video monitor, printer, and speaker.

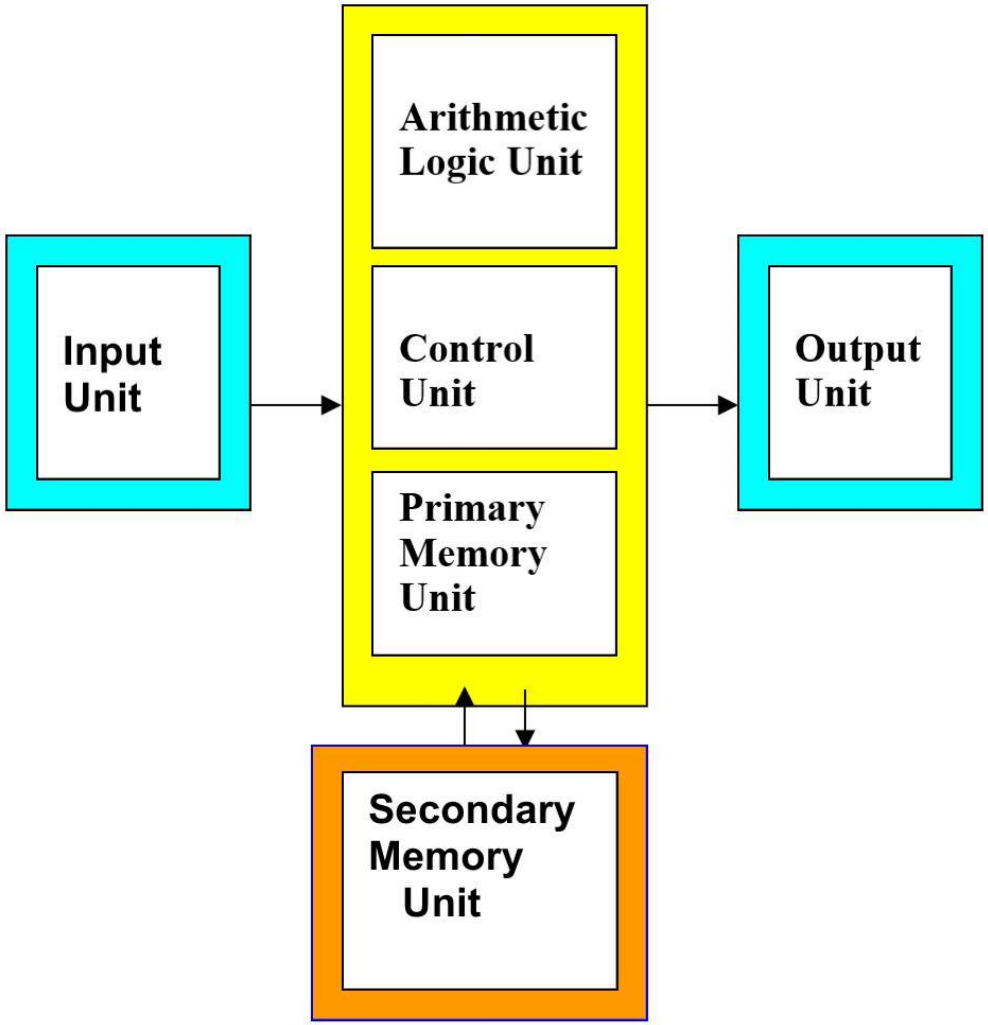
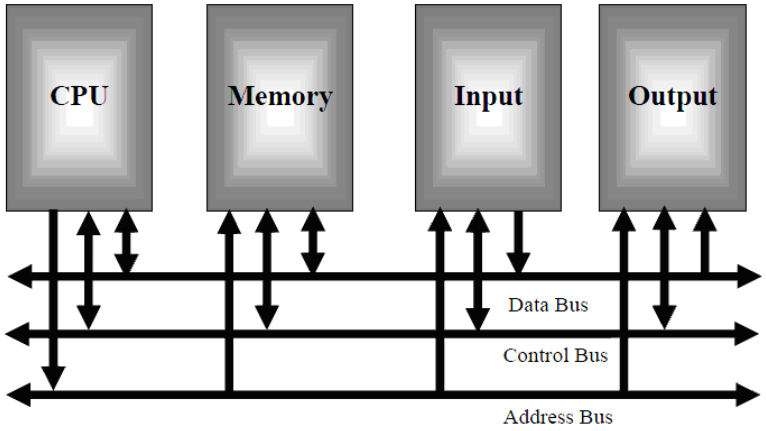


Figure (1): Computer Components

Connecting these units by three sets of parallel lines called buses. The three buses are the address bus, the data bus, and the control bus. Figure (3) shows these connections.

The *data bus* consists of parallel signal lines. As indicated by the double-ended arrows on the data bus line in Figure 1, the data bus lines are bidirectional. This means that the CPU can read data in from memory or from a port on these lines, or it can send data out to memory or to a port on these lines.



Figure(3): Von Neumann model of computer architecture

The *address bus* consists of parallel signal lines. On these lines the CPU sends out the address of the memory location that is to be written to or read from. The number of memory locations that the CPU can address is determined by the number of address lines. When the CPU reads data from or writes data to a port, it sends the port address out on the address bus.

The *control bus* consists of parallel signal lines. The CPU sends out signals on the control bus to enable the outputs of addressed memory devices or port devices.

Central Processing Unit (CPU)

The processor; it controls and manipulates data to produce information. In a microcomputer the CPU is usually contained on a single integrated circuit or chip called a microprocessor. This chip and other components that make it work are mounted on a circuit board called a motherboard.

The CPU is comprised of three parts:

1. Arithmetic Logic Unit (ALU) 2. Control Unit 3. Primary Memory Unit

The *ALU* consists of the arithmetic unit and the logic unit. The function of the arithmetic unit is to execute basic operations such as addition, subtraction, multiplication and division. The arithmetic unit can also provide logarithmic, trigonometric, and other mathematical functions by combining the basic arithmetic operations. The logic unit makes comparisons and takes action based on the results. In this unit, numbers and conditions are compared. Greater than, less than, equal to, not equal to, and, or, and not are some examples of logic functions.

The *Control Unit* coordinates and supervises the function of the entire computer system. It synchronizes the CPU tasks by using a system clock which releases timely electrical pulses. The time required to get data from the primary memory and interpret it is called *Instruction time (I-time)* and time required to execute data is called *Execution time (E-time)*. The clock speed is measured in megahertz (MHZ).One hertz is the completed cycle in a second, a megahertz being equal to one million cycles per second. Today, microprocessors have different execution speeds. Under equal conditions, a 16-MHZ processor will be twice as fast as an 8-MHZ processor.

Memory

Computer memory is the storage space in computer where data is to be processed and instructions required for processing are stored. The memory is divided into large number of small parts called cells. Each location or cell has a unique address which varies from zero to memory size minus one. For example if computer has 64k words, then this memory unit has 64 * 1024=65536 memory locations.

Memory is primarily of three types

1-Cache Memory
2-Primary Memory/Main Memory
3-Secondary Memory

1-Cache Memory

Cache memory is a very high speed semiconductor memory which can speed up CPU. It acts as a buffer between the CPU and main memory. It is used to hold those parts of data and program which are most frequently used by CPU. The parts of data and programs are transferred from disk to cache memory by operating system, from where CPU can access them.

Advantages

The advantages of cache memory are as follows

1- Cache memory is faster than main memory.

2- It consumes less access time as compared to main memory.

3- It stores the program that can be executed within a short period of time.

4-It stores data for temporary use.

Disadvantages

The disadvantages of cache memory are as follows

1- Cache memory has limited capacity.

2- It is very expensive.

1- Primary Memory (Main Memory)

Primary memory holds only those data and instructions on which computer is currently working. It has limited capacity and data is lost when power is switched off. The data and instruction required to be processed reside in main memory. It is divided into two subcategories RAM and ROM.

Characteristics of Main Memory

1- These are semiconductor memories.

2- It is known as main memory.

3- Usually volatile memory.

4- Data is lost in case power is switched off.

5- It is working memory of the computer.

6- Faster than secondary memories.

7- A computer cannot run without primary memory.

1-Secondary Memory

This type of memory is also known as external memory or non-volatile. It is slower than main memory. These are used for storing data/Information permanently. CPU directly does not access these memories instead they are accessed via input-output routines. Contents of secondary memories are first transferred to main memory, and then CPU can access it. For example: disk, CD-ROM, DVD & USB… etc.

Characteristic of Secondary Memory

1- These are magnetic and optical memories.
2- It is known as backup memory.
3- It is non-volatile memory.
4- Data is permanently stored even if power is switched off.
5- It is used for storage of data in a computer.
6- Computer may run without secondary memory.
7- Slower than primary memories.

RAM

(Random Access Memory) is the internal memory of the CPU for storing data, program and program result. It is read/write memory which stores data while the machine is working. As soon as the machine is switched off, data is erased. Access time in RAM is independent of the address that is, each storage location inside the memory is as easy to reach as other locations and takes the same amount of time. Data in the RAM can be accessed randomly but it is very expensive.

The type of RAM is:

1- Static RAM (SRAM)

2- Dynamic RAM (DRAM)

1-Static RAM (SRAM)

The word static indicates that the memory retains its contents as long as power is being supplied. However, data is lost when the power gets down due to volatile nature. SRAM chips use a matrix of 6-transistors and no capacitors. Transistors do not require power to prevent leakage, so SRAM need not have to be refreshed on a regular basis. Because of the extra space in the matrix, SRAM uses more chips than DRAM for the same amount of storage space, thus making the manufacturing costs higher. So SRAM is used as cache memory and has very fast access.

Characteristic of the Static RAM

1- It has long life

2- There is no need to refresh

3- Faster

4- Used as cache memory

5- Large size

6- Expensive

7- High power consumption

1-Dynamic RAM (DRAM)

DRAM, unlike SRAM, must be continually refreshed in order to maintain the data. This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second. DRAM is used for most system memory because it is cheap and small. All DRAMs are made up of memory cells which are composed of one capacitor and one transistor.

Characteristics of the Dynamic RAM

1- It has short data lifetime
2- Need to be refreshed continuously
3- Slower as compared to SRAM
4- Used as RAM
5- Lesser in size
6- Less expensive
7- Less power consumption

ROM

The memory from which we can only read but cannot write on it this type of memory is non-volatile. The information is stored permanently in such memories during manufacture. A ROM, stores such instructions that are required to start a computer. This operation is referred to as bootstrap. ROM chips are not only used in the computer but also in other electronic items like washing machine and microwave oven.

The various types of ROM is:

1-PROM (Programmable Read only Memory)

PROM is read-only memory that can be modified only once by a user. The user buys a blank PROM and enters the desired contents using a PROM program. Inside the PROM chip there are small fuses which are burnt open during programming. It can be programmed only once and is not erasable.

2-EPROM (Erasable and Programmable Read Only Memory)

The EPROM can be erased by exposing it to ultra-violet light. During programming, an electrical charge is trapped in an insulated gate region.For erasing this charge, ultra-violet light is passed through a quartz crystal window. This exposure to ultra-violet light dissipates the charge.

3-EEPROM
(Electrically Erasable and Programmable Read Only Memory)

The EEPROM is programmed and erased electrically. It can be erased and reprogrammed about ten thousand times. Both erasing and programming take about 4 to 10 ms (milli second). In EEPROM, any location can be selectively erased and programmed. EEPROMs can be erased one byte at a time, rather than erasing the entire chip. Hence, the process of re-programming is flexible but slow.

Advantages of ROM **The advantages of ROM are as follows:**

1- Non-volatile in nature
2- These cannot be accidentally changed
3- Cheaper than RAMs
4- Easy to test
5- More reliable than RAMs
6- These are static and do not require refreshing

Computer Software

A binary or base two, system has two states, ON or OFF. Any kind of electronic switch has only two states which are symbolized by 0 for OFF and 1 for ON. In computer terminology each o or 1 is called a *bit*, and a combination of eight bits is a byte. Each byte represents a character whether alphabetical, numerical, or symbolic. The programs for binary computers have to be written with binary numbers, which is called *machine language*.

As you know computer cannot do anything on its own and has to be guided by the user. In order to do any specific job you have to give a sequence of instructions to the computer. This set of instructions is called a *computer program*. *Software* refers to the set of computer programs. We can say that it is the collection of programs, which increases the capabilities of the hardware. Software guides the computer at every step where to start and stop during a particular job. The process of software development is called *programming*.

You should keep in mind that software and hardware are complementary to each other. Both have to work together to produce meaningful result. Another important point you should know that developing software is difficult, time consuming and expensive.

Computer software is normally classified into two broad categories:

1- Application Software

2- System Software

1- Application Software: Application software is a set of programs, which are written to perform specific tasks of the users of computers such as Accounts, Stores, etc. These software are developed in high level language to help the user to get the computer perform the tasks.

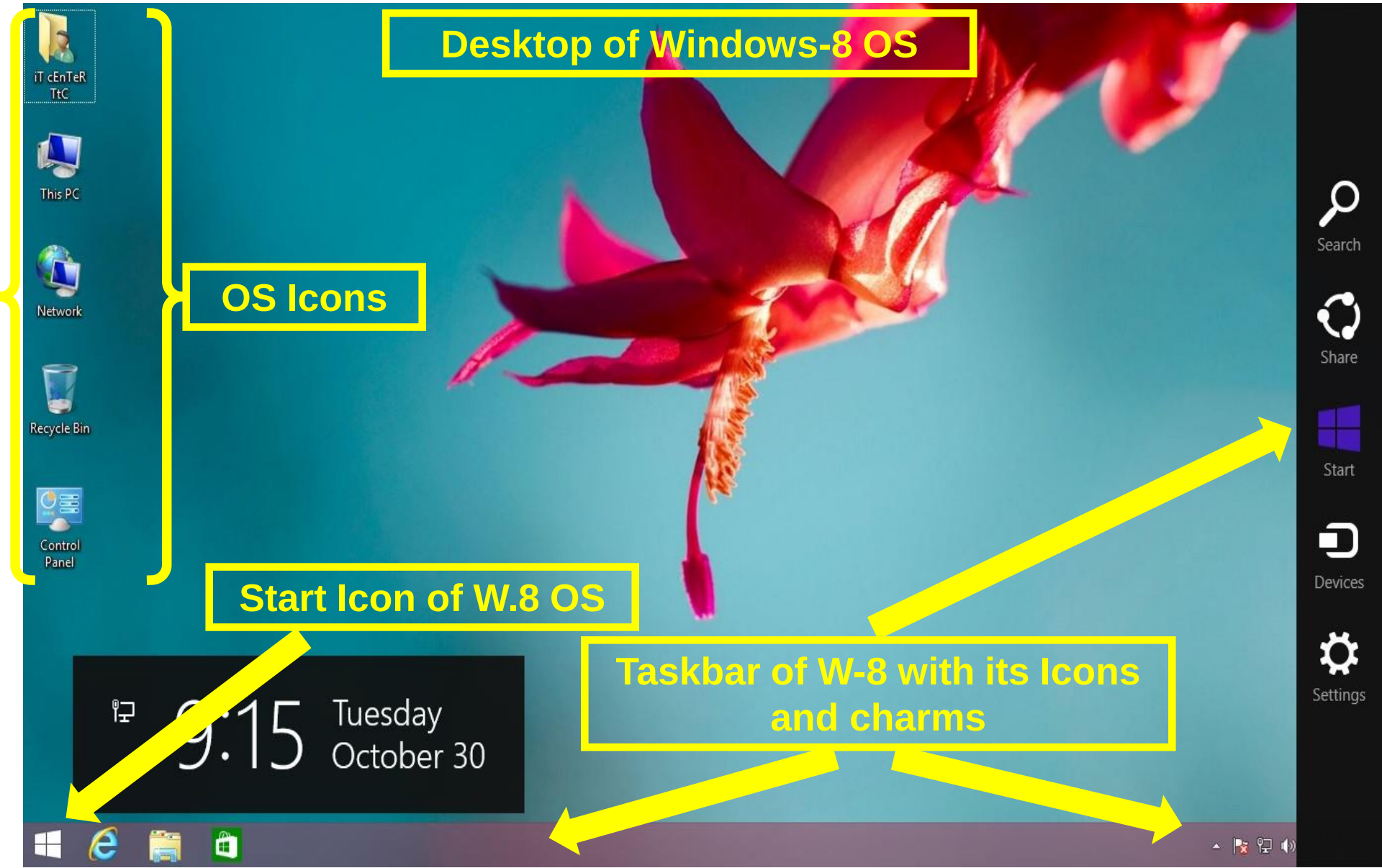
2-System Software: System software may be defined as a set of one or more programs designed to control the operations of computer system. System Software are general purpose programs designed for performing tasks such as controlling all operations required to move data into and out of the computer. It communicates with keyboard, printer, card reader, disk, tapes etc. It also monitors the use of various hardware like memory, CPU, … etc. System software acts as an interface between hardware and application software. System software allows application packages to be run on the computer with less time and effort. Remember that it is not possible to run application software without system software.

All computers run software called the *operating system*. The operating system allows the computer to run other software and to perform basic tasks, such as communicating between the computer and the user, keeping track of files and folders, and controlling peripheral devices.

When a computer is turned on, the operating system software is automatically loaded into the computer's memory from the hard disk in a process called *booting*.

Examples of operating systems include Windows XP, Vista, 7, 8, 10, Linux, and Mac OS X. Windows XP has a graphical user interface or GUI that displays open applications and documents in areas on the screen called *windows*. Placing each open application into its own window allows Windows XP to multitask. *Multitasking* is an operating system feature that allows more than one application to run at a time.

When the Windows ⅄ operating system is running, the computer screen is referred to as the *Desktop* :



Programming Language

There are two major types of programming languages. These are Low Level Languages and High Level Languages. Low Level languages are further divided into Machine language and Assembly language.

1-Low level languages

The term low level means closeness to the way in which the machine has been built. Low Level languages are machine oriented and require extensive knowledge of computer hardware and its configuration. The low level languages are:

1- Machine Language: Machine Language is the language of the computer and is the only language that is directly understood by the computer. We also call it machine code and it is written as strings of 1's and 0's. It is on this basis that the computer is designed. When this sequence of codes is fed to the computer, it recognizes the codes and converts it in to electrical signals needed to run it. For example, a program instruction may look like this:

1011000111101

Advantage:

The only advantage is that program of machine language run very fast because no translation program is required for the CPU.

Disadvantages:

1. **It is very difficult to program in machine language. The programmer has to know details of hardware to write program.**
2. **Machine language is hardware dependent.**
3. **The programmer has to remember a lot of codes to write a program, whichresults in program errors.**
4. **It is difficult to debug the program.**

2-Assembly Language: It is the first step to improve the programming structure. In this language, the machine codes comprising of 1's and 0's are substituted by symbolic codes (called mnemonic codes) to improve their understanding. The set of symbols and letters forms the assembly language and a translator program (called Assembler) is required to translate the programs written in assembly language into machine language for execution by the computer. It is considered to be a second-generation language.

Advantages:

1. The symbolic programming of Assembly Language is easier to understand and saves a lot of time and effort of the programmer.

2. It is relatively easier to correct errors and modify program instructions.

3. Assembly Language has almost the same efficiency of execution as the Machine level language because this is one-to-one translator between Assembly language program and its corresponding machine language Program.

Disadvantages:

One of the major disadvantages is that assembly language is machine dependent. A program written for one computer might not run on other computers with different hardware configuration.

1-High Level Languages

High-level languages are simple language that use English and mathematical symbols like +, -, %, /, etc. for its program construction. You should know that any higher-level language has to be converted to machine language for the computer to understand.

A variety of higher-level languages have become popular. The first of these was FORmula TRANslation(FORTRAN), which was developed to solve scientific problems where a large number of calculations are required. Common Business Oriented Language (COBOL) was designed to solve data processing problems in businesses.

Advantages

Higher-level languages have a major advantage over machine and assembly languages that higher-level languages are easy to learn and use. It is because that they are similar to the languages used by us in our day-to-day life. The programs can easily be debugged and are machine independent.

Compiler

It is a program that translates the instructions of higher-level languages to machine language. It is called compiler because it compiles every program instruction given in higher-level languages into machine language.

Thus compiler is a program translator like assembler but more sophisticated. It scans the entire program first and then translates it into machine code. The program written by the programmer in higher-level language is called source program. After this program is converted to machine language by the compiler it is called object program.

Interpreter

An interpreter is another type of program translator used for translating higher-level language instructions into machine language instructions. It takes one statement of higher-level language at a time, translates it into machine language and executes it immediately. Translation and execution are carried out for each statement. It differs from compiler, which translate the entire source program into machine code and then involve in its execution.

The advantage of interpreter compared to compiler is its fast response to changes in source program. Interpreters are easy to write and do not require large memory in computer. The disadvantage of interpreter is that it is time-consuming method because each time a statement in a program is executed, it is first translated. Thus compiled machine language program runs much faster than an interpreted program.

Files & Folders

A file is a collection of related data stored on a lasting medium such as a hard disk, a CD, or a diskette. Once a file has been saved, it can be loaded into memory for further editing at a later time. A file must be given a name to identify it. A file name is a unique name for a file stored on disk. File names can contain letters, numbers, spaces, and the underscore character (_). File names cannot contain colons (:), asterisks (*), question marks (?), and some other special characters. A file extension indicates what application the file was created in.. Folders are used to organize commonly related files.

Lecture No….2

Binary Decimal Octal and Hexadecimal number system

A number can be represented with different base values. We are familiar with the numbers in the base 10 (known as decimal numbers), with digits taking values 0,1,2,…,8,9.

A computer uses a Binary number system which has a base 2 and digits can have only TWO values: 0 and 1.

A decimal number with a few digits can be expressed in binary form using a large number of digits. Thus the number 65 can be expressed in binary form as 1000001.

The binary form can be expressed more compactly by grouping 3 binary digits together to form an octal number. An octal number with base 8 makes use of the EIGHT digits 0,1,2,3,4,5,6 and 7.

A more compact representation is used by Hexadecimal representation which groups 4 binary digits together. It can make use of 16 digits, but since we have only 10 digits, the remaining 6 digits are made up of first 6 letters of the alphabet. Thus the hexadecimal base uses 0,1,2,….8,9,A,B,C,D,E,F as digits.

To summarize
Decimal : base 10
Binary : base 2
Octal: base 8
Hexadecimal : base 16

Decimal	Binary	Octal	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Base 10

Decimal Number System

Base 10

The number system that we use in our day-to-day life is the decimal number system. Decimal number system has base 10 as it uses 10 digits from 0 to 9. In decimal number system, the successive positions to the left of the decimal point represent units, tens, hundreds, thousands and so on.

Each position represents a specific power of the base (10). For example, the decimal number 1234 consists of the digit 4 in the unit's position, 3 in the tens position, 2 in the hundreds position and 1 in the thousands position and its value can be written as:

$(1x1000)+ (2x100)+ (3x10)+ (4xl)$

$(1x10^3)+ (2x10^2)+ (3x10^1)+ (4xl0^0)$

$1000 + 200 + 30 + 4$

1234

Base 10

Base 10

Base 2

Base 2

Binary Number System

Characteristics of binary number system are as follows

- Uses two digits, 0 and 1
- Also calle
- Last posit
- Example 2

e base (2).

Example

Binary Number: 10101_2

Calculating Decimal Equivalent:

Step	Binary Number	Decimal Number
Step 1	10101_2	$((1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0))_{10}$
Step 2	10101_2	$(16 + 0 + 4 + 0 + 1)_{10}$
Step 3	10101_2	21_{10}

Note: 10101_2 is normally written as 10101.

Base 2

Base 2

Base 8

Octal Number System

Base 8

Characteristics of octal number system are as follows:

. Uses eight digits, 0,1,2,3,4,5,6,7.

Iso called base 8 number system

Last position in an octal number represents a x power of the base (8).

Example 8x where x represents the last position - 1.

Example

Octal Number: 12570_8

Calculating Decimal Equivalent:

Step	Octal Number	Decimal Number
Step 1	12570_8	$((1 \times 8^4) + (2 \times 8^3) + (5 \times 8^2) + (7 \times 8^1) + (0 \times 8^0))_{10}$
Step 2	12570_8	$(4096 + 1024 + 320 + 56 + 0)_{10}$
Step 3	12570_8	5496_{10}

Note: 12570_8 is normally written as 12570.

Base 8

Base 8

Base 16

Hexadecimal Number System

Base 16

Characteristics of hexadecimal number system are as follows. Uses 10 digits and 6 letters, 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F.

Letters , C = 12, D = 13,

Also c

La a x po ents the las

Example

Hexadecimal Number: $19FDE_{16}$

Calculating Decimal Equivalent:

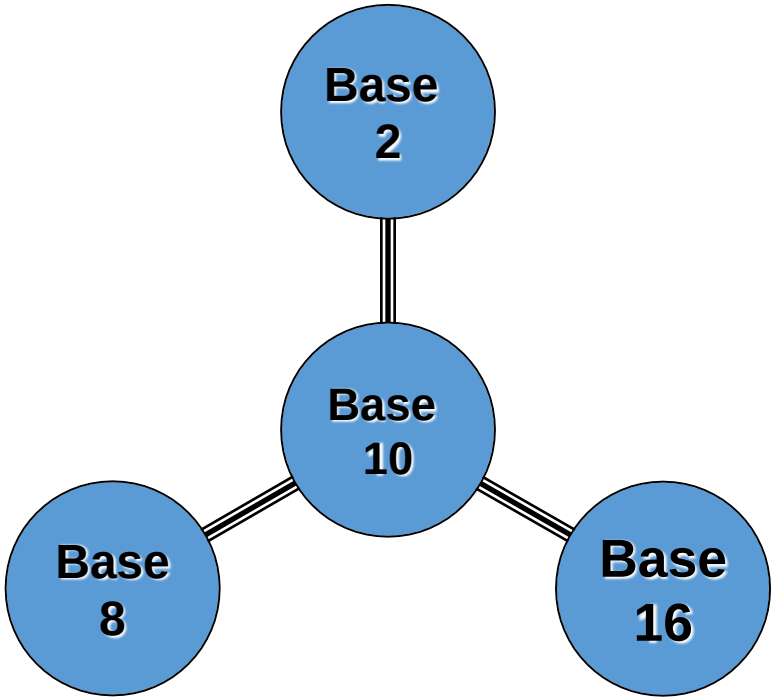
Step	Binary Number	Decimal Number
Step 1	$19FDE_{16}$	$((1 \times 16^4) + (9 \times 16^3) + (F \times 16^2) + (D \times 16^1) + (E \times 16^0))_{10}$
Step 2	$19FDE_{16}$	$((1 \times 16^4) + (9 \times 16^3) + (15 \times 16^2) + (13 \times 16^1) + (14 \times 16^0))_{10}$
Step 3	$19FDE_{16}$	$(65536 + 36864 + 3840 + 208 + 14)_{10}$
Step 4	$19FDE_{16}$	106462_{10}

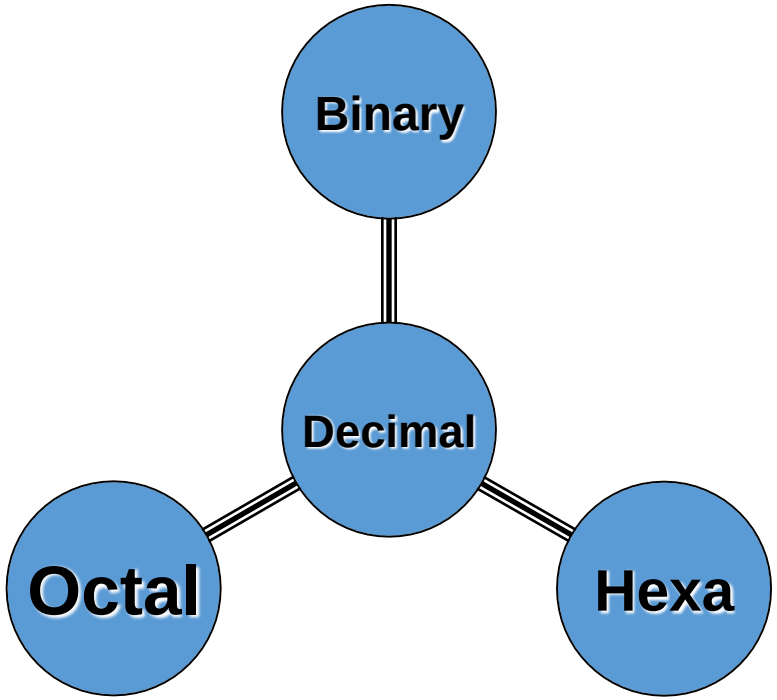
Note: $19FDE_{16}$ is normally written as 19FDE.

Base 16

Base 16

Number Conversion





Base 10

Decimal to Other Base System

Other Base

Step 1 - Divide the decimal number to be converted by the value of the new base.

Step 2 - Get the remainder from Step 1 as the rightmost digit (least significant digit) of new base number.

Step 3 - Divide the quotient of the previous divide by the new base.

Step 4 - Record the remainder from Step 3 as the next digit (to the left) of the new base number.

Repeat Steps 3 and 4, getting remainders from right to left, until the quotient becomes zero in Step 3. The last remainder thus obtained will be the most significant digit (MSD) of the new base number.

Example

Decimal Number: 29_{10}

Calculating Binary Equivalent:

Step	Operation	Result	Remainder
Step 1	29 / 2	14	1
Step 2	14 / 2	7	0
Step 3	7 / 2	3	1
Step 4	3 / 2	1	1
Step 5	1 / 2	0	1

As mentioned in Steps 2 and 4, the remainders have to be arranged in the reverse order so that the first remainder becomes the least significant digit (LSD) and the last remainder becomes the most significant digit (MSD). Decimal Number: 29= Binary Number: 1110.

Other Base

Base 10

Other base system to Decimal System

Step 1 - Determine the column (positional) value of each digit (this depends on the position of the digit and the base of the number system).

Step 2 - Multiply the obtained column values (in Step 1) by the digits in the corresponding columns.

Step 3 - Sum the products calculated in Step 2. The total is the equivalent value in decimal.

Example

Binary Number: 11101_2

Calculating Decimal Equivalent:

Step	Binary Number	Decimal Number
Step 1	11101_2	$((1 \times 2^4) + (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0))_{10}$
Step 2	11101_2	$(16 + 8 + 4 + 0 + 1)_{10}$
Step 3	11101_2	29_{10}

Binary Number: 11101_2 = Decimal Number: 29_{10}

Other Base System to Non-Decimal System

Step 1 - Convert the original number to a decimal number (base 10).

Step 2 - Convert the decimal number so obtained to the new base Number

Example

Octal Number: 25_8

Calculating Binary Equivalent:

Step 1: Convert to Decimal

Step	Octal Number	Decimal Number
Step 1	25_8	$((2 \times 8^1) + (5 \times 8^0))_{10}$
Step 2	25_8	$(16 + 5)_{10}$
Step 3	25_8	21_{10}

Octal Number: 25_8 = Decimal Number: 21_{10}

Step 2: Convert Decimal to Binary

Step	Operation	Result	Remainder
Step 1	21 / 2	10	1
Step 2	10 / 2	5	0
Step 3	5 / 2	2	1
Step 4	2 / 2	1	0
Step 5	1 / 2	0	1

Decimal Number: 21_{10} = Binary Number: 10101_2

Octal Number: 25_8 = Binary Number: 10101_2

Base 2

Base 8

Shortcut method - Binary to Octal

Step 1 - [illegible] starting from th[illegible]

Step 2 - [illegible] one octal digit.

Example

Binary Number: 10101_2

Calculating Octal Equivalent:

Step	Binary Number	Octal Number
Step 1	10101_2	010 101
Step 2	10101_2	2_8 5_8
Step 3	10101_2	25_8

Binary Number: 10101_2 = Octal Number: 25_8

Base 8

Base 2

Shortcut method - Octal to Binary

Steps 1 - Convert each octal digit to a 3 digit binary number (the octal digits may be treated as decimal for this conversion).

Step 2 - Combine all the resulting binary groups (of 3 digits each) into a single binary number.

Example

Octal Number: 25_8

Calculating Binary Equivalent:

Step	Octal Number	Binary Number
Step 1	25_8	$2_{10}\ 5_{10}$
Step 2	25_8	$010_2\ 101_2$
Step 3	25_8	010101_2

Octal Number: 25_8 = Binary Number: 10101_2

Base 2

Base 8

Shortcut method - Binary to Hexadecimal

Step 1 - Divide the binary digits into groups of four (starting from the right).

Step 2 - Convert each group of four binary digits to one hexadecimal symbol.

EXAMPLE

Binary Number: 10101_2

Calculating hexadecimal Equivalent:

Step	Binary Number	Hexadecimal Number
Step 1	10101_2	0001 0101
Step 2	10101_2	$1_{10}\ 5_{10}$
Step 3	10101_2	15_{16}

Binary Number: 10101_2 = Hexadecimal Number: 15_{16}

Base 2

Base 8

Shortcut method - Hexadecimal to Binary

Steps 1 - Convert each hexadecimal digit to a 4 digit binary number (the hexadecimal digits may be treated as decimal for this conversion).

Example

Hexadecimal Number: 15_{16}

Calculating Binary Equivalent:

Step	Hexadecimal Number	Binary Number
Step 1	15_{16}	$1_{10}\,5_{10}$
Step 2	15_{16}	$0001_2\,0101_2$
Step 3	15_{16}	00010101_2

Hexadecimal Number: 15_{16} = Binary Number: 10101_2

Step 2 - Combine all the resulting binary groups (of 4 digits each) into a single binary num

Questions

1- Covert the octal number 675 to decimal.
2- Convert the binary number 11011011 to hex.
3-Convert the hex number ABC7 to octal.
4- Convert the decimal number 497 to binary.
5-Convert the hex number DE9A to octal.
6- Convert the octal number 4536 to hexadecimal by using shortcut method.
7-Which of the following are not valid numbers in the radix indicated?

11111_2 827_8 DEF_{16}

8-How much memory is supported by a system with 24-bit memory Addresses?
9-How many bits are needed to address a memory of 4GB?
10- What is the biggest binary number you can write with 5 bits?