



TOPIC 2: COMPUTER HARDWARE

Unit Two: Processing Devices

Unit Two: Processing Devices



■ **Unit Summary:-**

Devices inside the system Unit:

- a) The system Unit**
 - Definitions, Components and parts.
- b) The Motherboard**
 - Definitions, Components and parts.
- c) The Central Processing Unit CPU**
 - Definitions, Components and parts.
- d) Memory (internal/primary storage)**
 - RAM and ROM, Memory Cache, CMOS,
 - Units of Measuring Computer Memory
 - Computer Data representation & numbering systems

a) The system unit



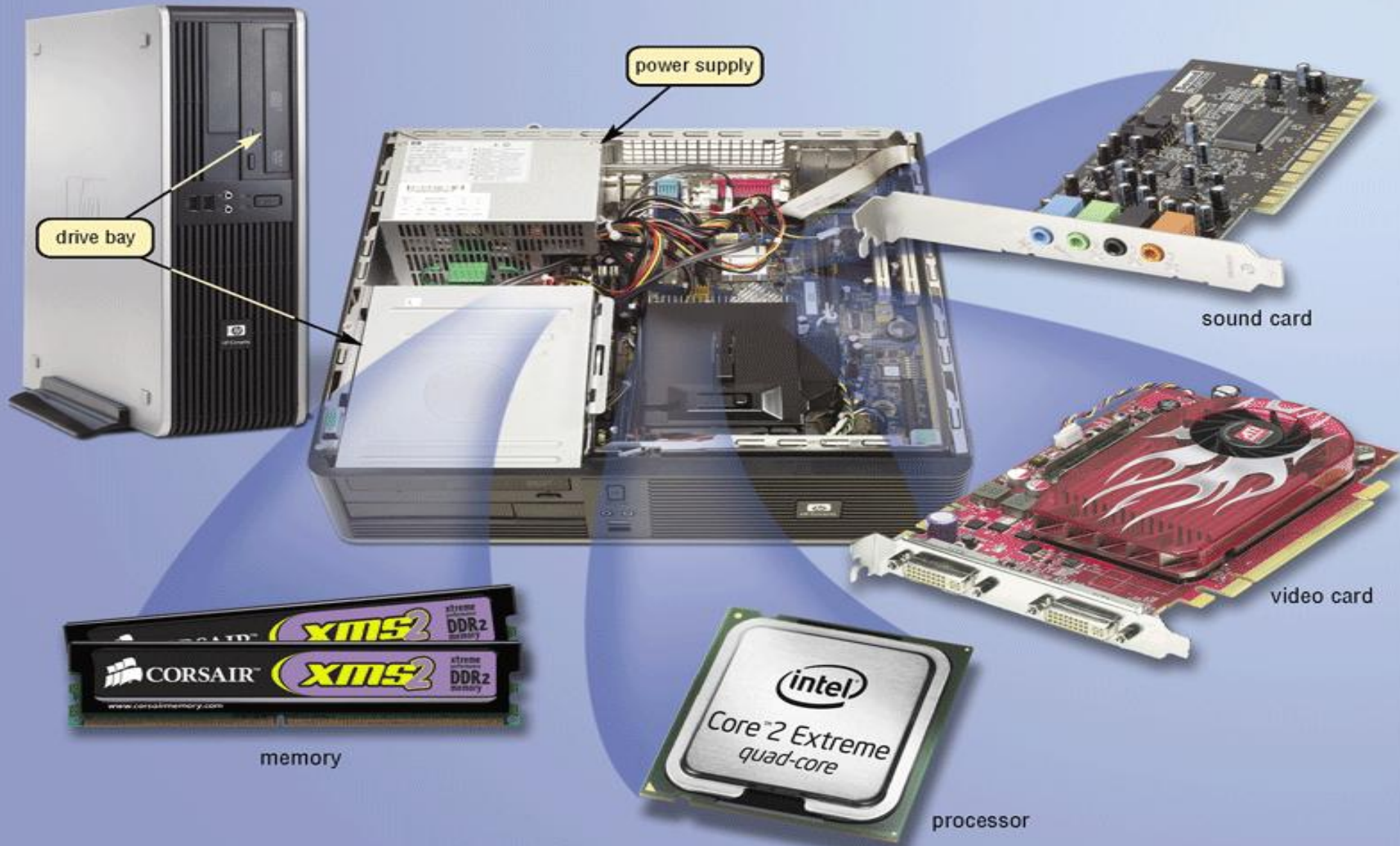
- Processing devices are the computer electronic components and chips housed in the system unit.
- *The system unit is a box-like case that houses the motherboard, the disks and drive bays, the power supply and cooling systems.*
- The components in the system unit are connected to the *motherboard*.
- *Two major components on the motherboard are the CPU and internal memory.*
- A drive bay is a rectangular opening inside the system unit that typically holds disk drives.

a) The system unit



All sizes of computers have a system unit

The system unit



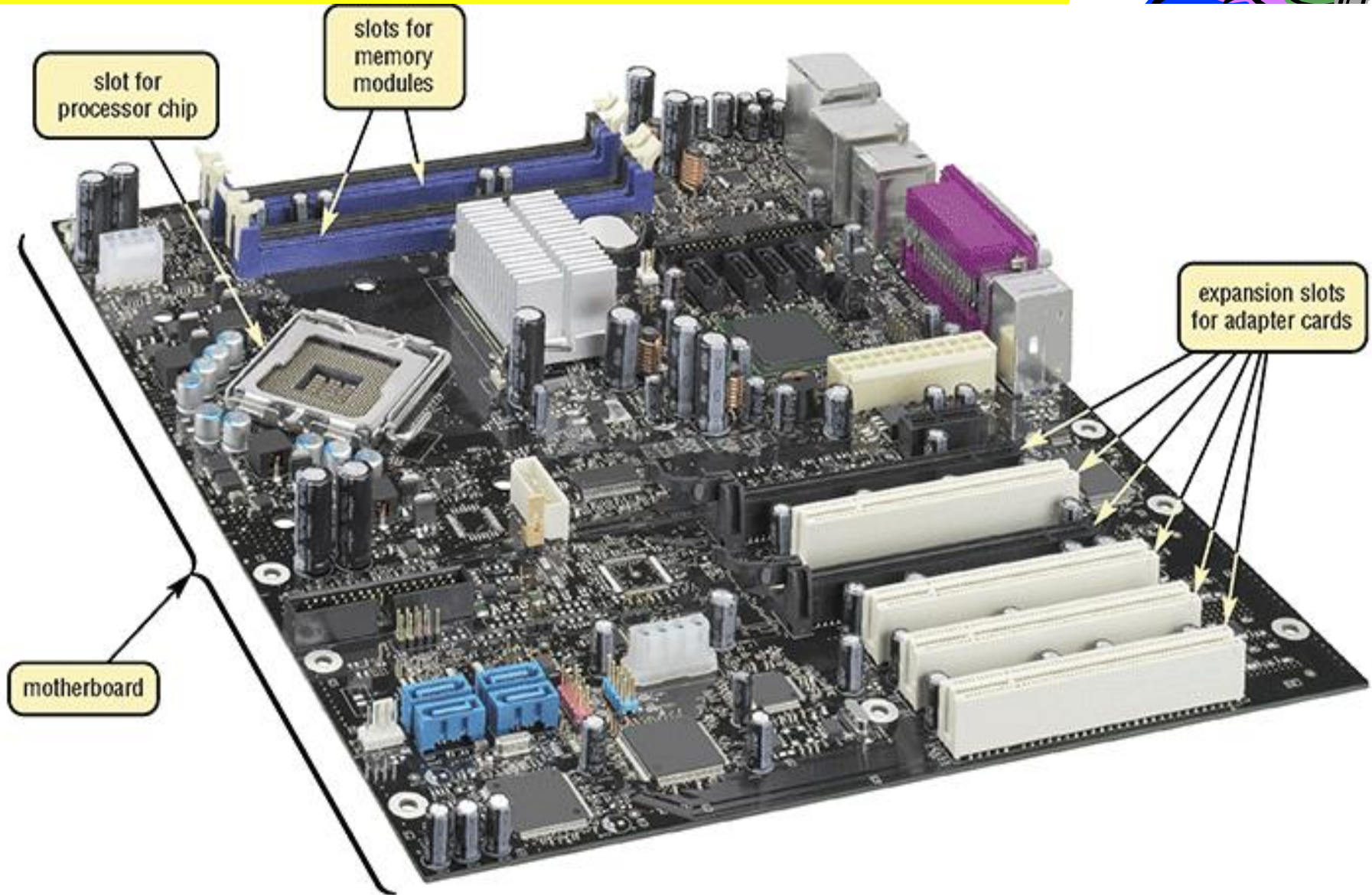
A system unit contains numerous electronic components

b) The motherboard



- The motherboard is a single circuit board, that provides the path through which the processor communicates with internal and peripheral devices.
- The motherboard is also called the *system board*
- The components attached to the motherboard include the processor chip, memory chips, support electronic circuitry, buses, and Expansion Slots for Adapter Cards.

Basic parts of a motherboard



Expansion slots and Adapter cards

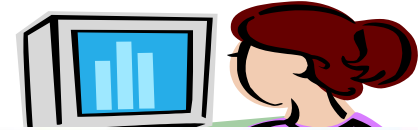


- An **expansion slot** is a socket on the motherboard that can hold an **adapter card**.
- An **adapter card**, also called expansion card, is a circuit board that increases the capabilities of the system or provides connections to peripherals.
- Some motherboards include all necessary capabilities and do not require adapter cards.
- Adapter cards are used for many supplemental capabilities, such as more memory, higher-quality sound devices, a modem, extra ports, or graphics capabilities.

An adapter card being inserted into an expansion slot



Currently used adapter cards and their functions



Adapter Card	Purpose
Disk controller	Connects disk drives
FireWire	Connects to FireWire devices
HDTV tuner	Allows viewing of HDTV broadcasts on the monitor
MIDI	Connects musical instruments
Modem	Connects other computers through telephone or cable television lines
Network	Connects other computers and peripherals
PC-to-TV converter	Connects a television
Sound	Connects speakers or a microphone
TV tuner	Allows viewing of television channels on the monitor
USB 2.0	Connects to USB 2.0 devices
Video	Connects a monitor
Video capture	Connects a video camera

Plug and Play (PnP)



- In the past, installing a card was not easy and required you to set switches and other elements on the motherboard.
- Today, many computers support *Plug and Play*.
- *PnP* refers to the computer's capability to automatically configure adapter cards and other peripherals as you install them when the computer is still running.

Buses



- The **bus** is a common electrical path, *that enables data flow between the various system components.*
- *A bus, allows the various devices inside and attached to the system unit to communicate with each other.*
- All buses consist of two parts:
- **The data bus** *which transfers actual data bits and*
- **The address bus** *which transfers information about where the data should go in memory.*

- fastest
- next fastest
- next fastest
- slowest

processor

system bus



memory

Buses allow the various devices inside and attached to the system unit to communicate with each other



PCI bus

PCI bus

system bus

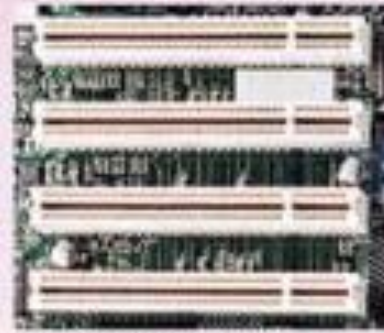
ISA bus

ISA bus (to other devices)

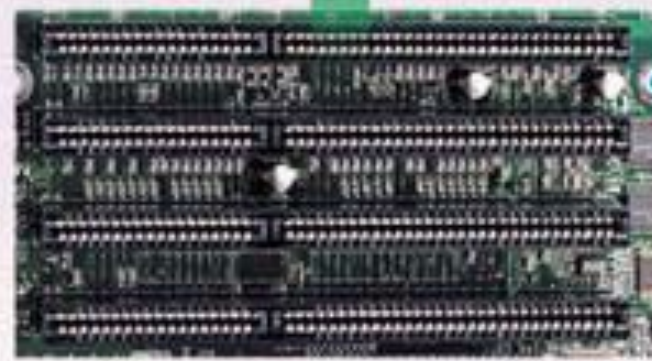


AGP bus slot

AGP bus



PCI bus expansion slots



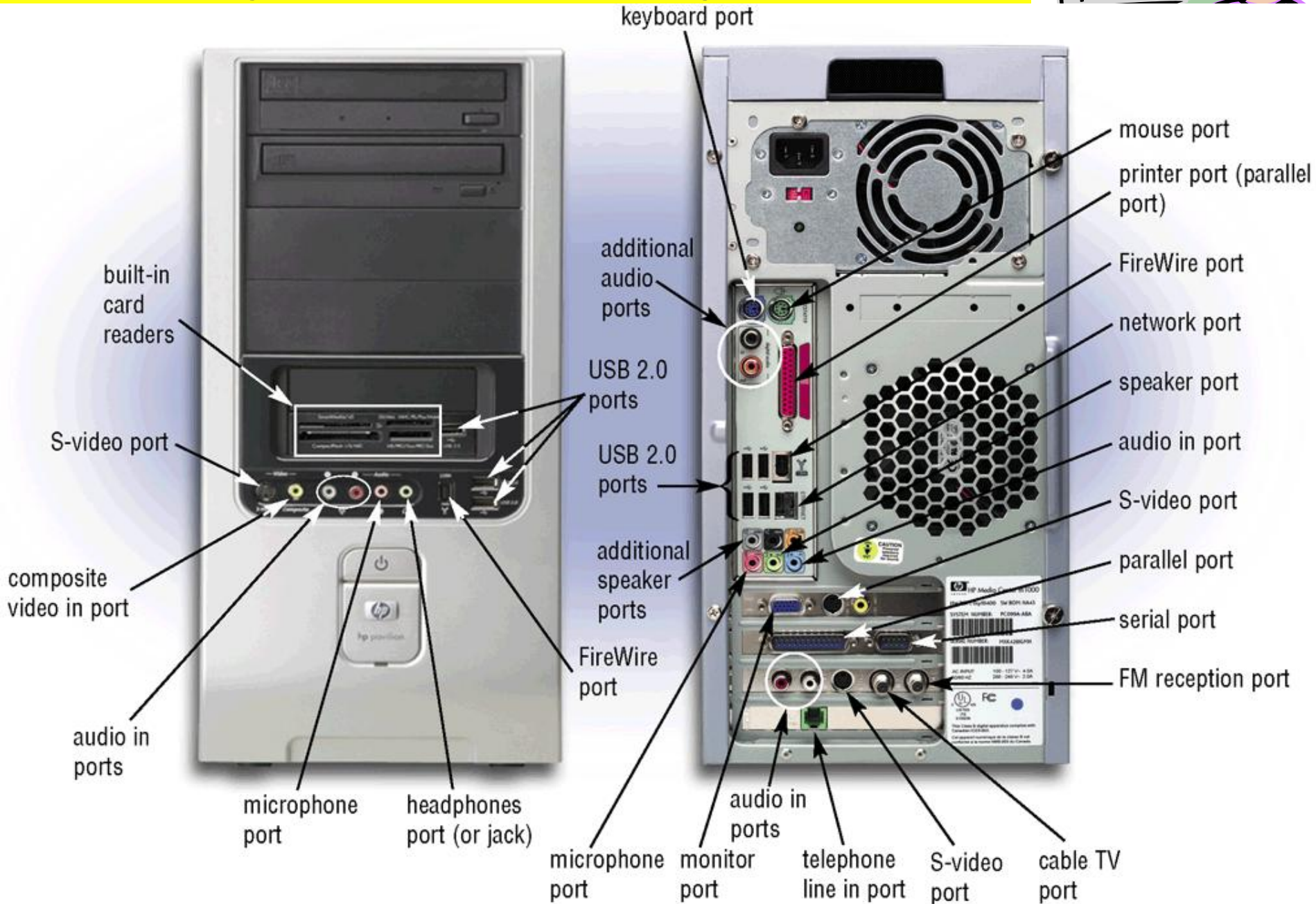
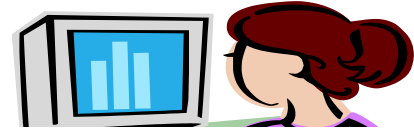
ISA bus expansion slots

Ports






















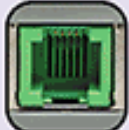




- ***A port is the point at which a peripheral attaches the system unit.***
- **Through a port, the peripheral can send data to or receive information from the computer.**
- **A peripheral device, such as a keyboard, monitor, printer, mouse, digital camera, and microphone, often attaches by a cable to a port on the system unit.**

A system unit has many ports



Examples of different types of ports on a system unit



Type	Picture	Type	Picture	Type	Picture	Type	Picture
Audio In		Monitor		FireWire		Side Surround Sound	
Cable TV		Mouse		FM reception		S/PDIF	
Center Surround Sound/Subwoofer		Network		HDMI port		Speaker	
Composite video in		Printer		Headphones		S-video	
Digital Video Interface (DVI)		Rear Surround Sound		Keyboard		Telephone line in	
eSATA port		Serial		Microphone		USB	

Common ports



- A **serial port** is a type of interface that connects a device to the system unit by transmitting data one bit at a time.
- A serial port has pin holes and usually connects devices such as mouse and keyboard.
- **Parallel Port** is a type of interface which connects devices to the system unit by transmitting data several bits at a time.
- **USB** (*Universal Serial Bus*) ports are used in high-speed device interfaces.
- **Bluetooth ports** use radio waves to transmit data between two devices, without using cables.

Connectors

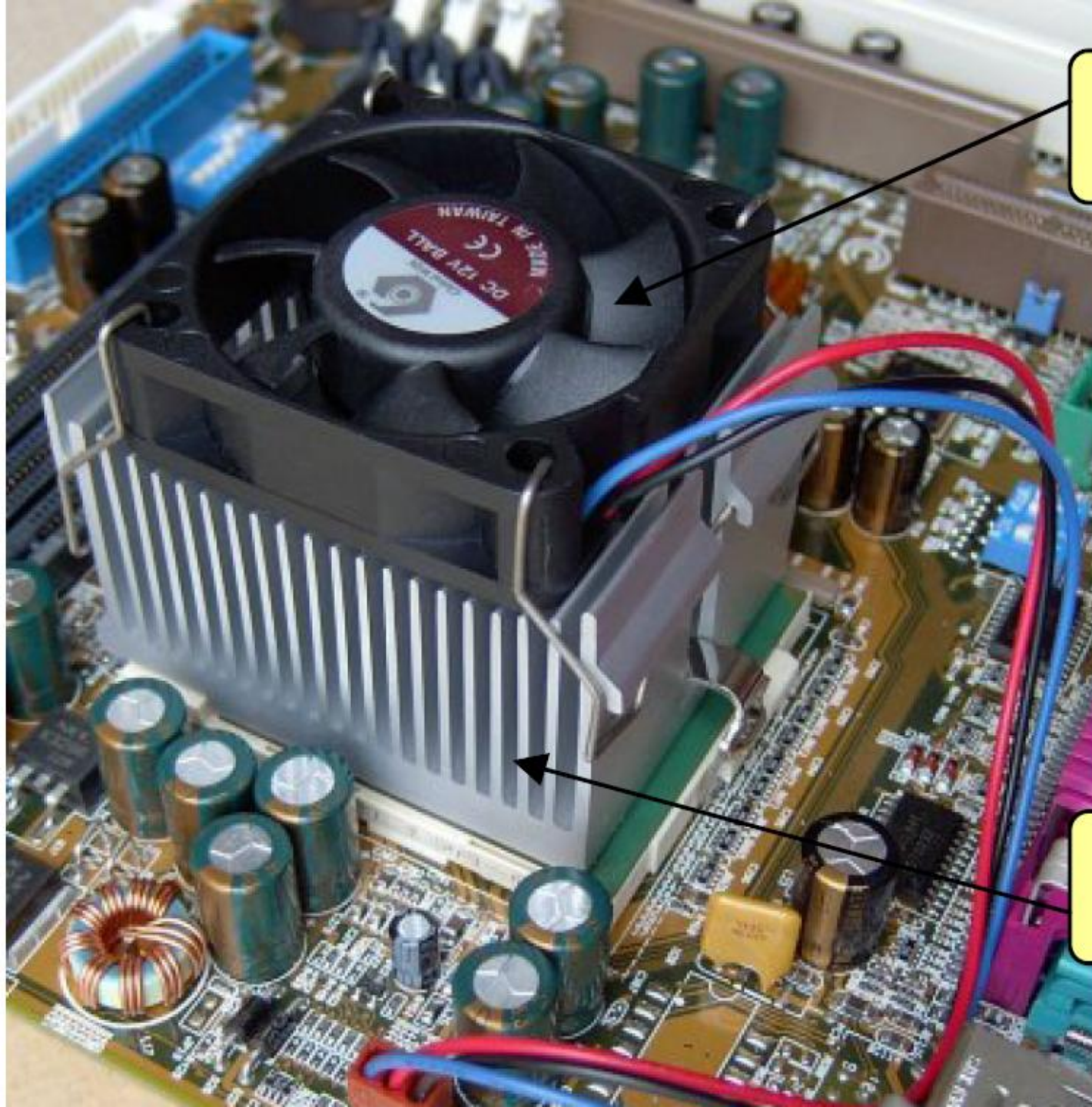


- *A connector joins a cable to a port.*
- *A connector at one end of a cable attaches to a port on the system unit, and a connector at the other end of the cable attaches to a port on the peripheral.*
- Most connectors are available in one of two genders: male and female.
- **Male connectors** have one or more exposed pins.
- **Female connectors** have matching holes to accept the pins on a male connector.

Power Supply and Cooling Technology



- The power supply is the component of the system unit that converts the wall outlet AC power of 110 to 240 volts into DC power of 0.5 to 12 volts
- Built into the power supply is a fan that keeps the power supply cool.
- Processor chips generate heat, which could cause the chip to burn up.
- A **heat sink** is a small ceramic or metal component with fins on its surface that absorbs and disperses heat produced by electrical components such as a processor.



Heat sink fan

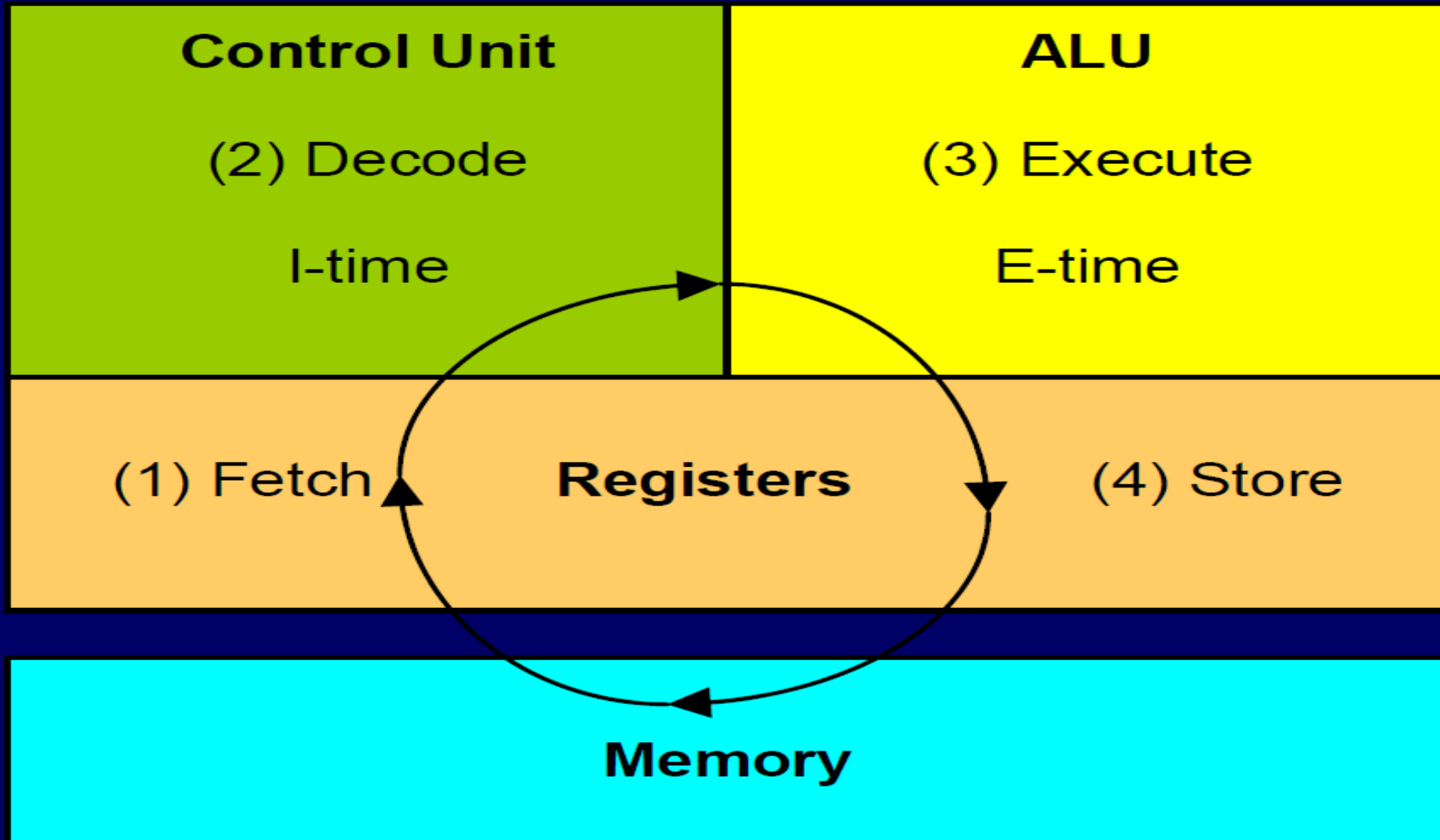
Heat sink

c) The CPU



- The *central processing unit (CPU)*, is a chip that interprets, carries out the basic instructions and manages most of a computer's operations.
- It is at referred to as the 'brain' of the computer.
- It has two basic sections: the control unit (CU) and the arithmetic/logic unit (ALU), which work together to perform the processing operations.
- *Other CPU components are the Registers and the System Clock.*

Components of a CPU.



The control unit (CU)



- The *control unit* is the component of the processor that directs and coordinates most of the operations in the computer.
- It interprets each instruction issued by program and then initiates the appropriate action to carry out the instruction.
- For every instruction, the control unit repeats a set of four basic steps called the machine cycle steps:

The machine cycle steps



- **Step 1: Fetching the instruction.** The instruction to be executed is obtained from memory.
- **Step 2: Decoding the instruction.** The instruction is translated into commands the computer understands and sent to the ALU.
- **Step 3: Executing the instruction.** The commands are carried out.
- **Step 4: Storing results.** The results are stored in registers or memory.

Arithmetic/logic unit (ALU),



- The ALU performs the arithmetic, comparison, and logical operations in a computer.
- It performs the execution step of a machine cycle.
- *Arithmetic operations include addition, subtraction, multiplication, and division.*
- *Logical operations work with conditions and logical operators such as AND, OR, and NOT.*
- For example, if you wanted to search a student database for Candidates of Computer studies, you would search for any students classified as 'Computer students AND listed under Candidates.

An example of a machine cycle



A student enters a math problem into the memory of the computer.



Step 1:

The control unit fetches the math problem's instructions and data from memory.

Step 2:

The control unit decodes the math problem's instructions and sends the instructions and data to the ALU.

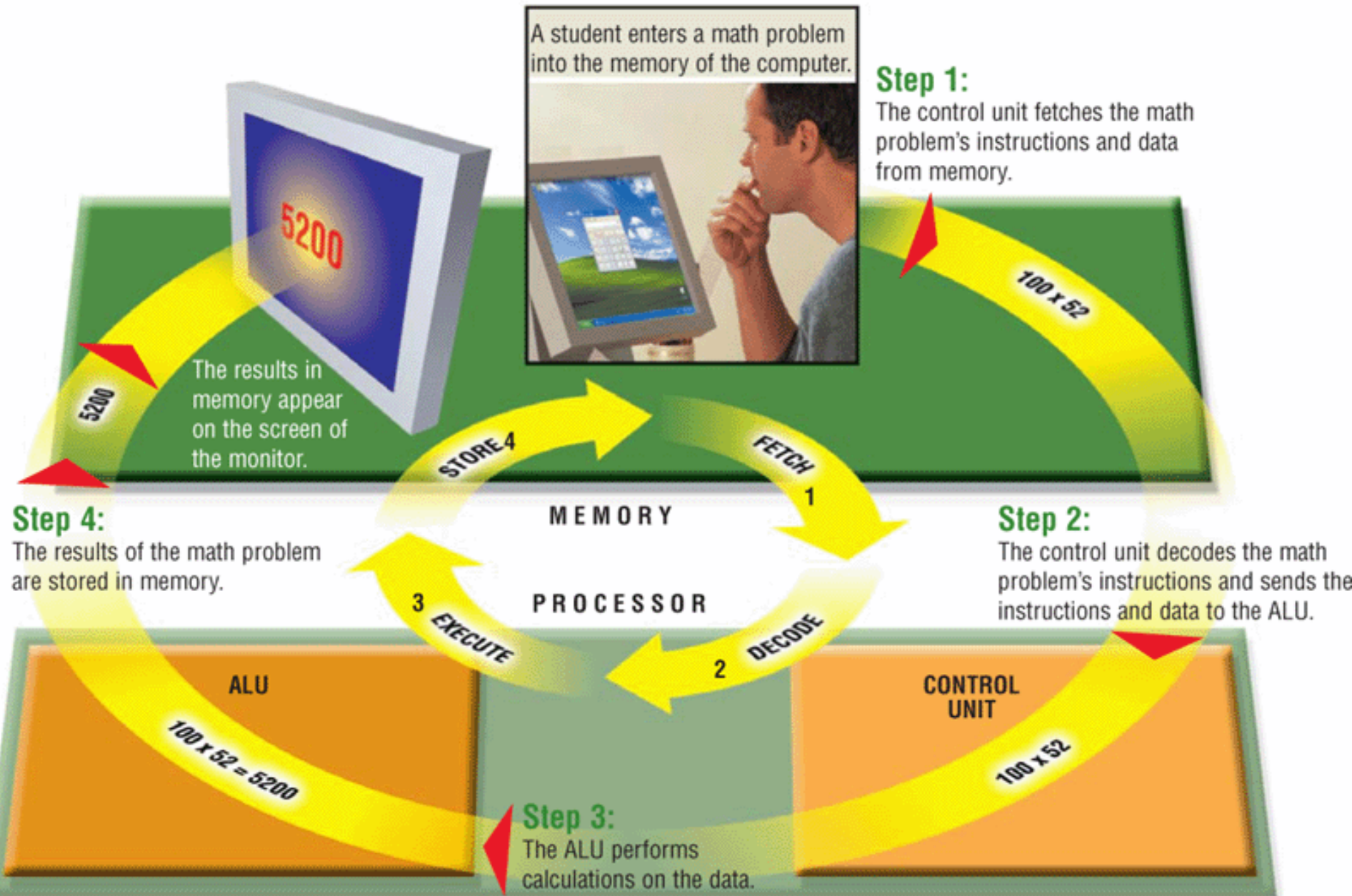
Step 3:

The ALU performs calculations on the data.

Step 4:

The results of the math problem are stored in memory.

The results in memory appear on the screen of the monitor.



Registers



- Registers are high-speed working storage areas *that temporarily hold instructions and data WITH IN THE CPU.*
- Registers work under the direction of the control unit to accept, hold, and transfer instruction or data and comparisons at high speed.
- Registers are not part of Memory or Secondary Storage: Registers hold data *immediately related to the operation being executed. Memory is used to store data that will be used in the near future. Secondary storage holds data that may be needed later (in future)*

Types of registers



- **Instruction register**, which contains the instruction being executed;
- **Address register**, which keeps track of where a given instruction or piece of data is stored in memory;
- **Storage register**, which temporarily holds data taken from or about to be sent to memory;
- **The Accumulator**, which collects the result of computations;
- **General-purpose register**, which is used for several functions, as assigned by the CU

The *system clock*



- The *system clock* is a small chip that is used by the CPU to synchronize the timing of all computer operations.
- The system clock generates electronic pulse or ticks at a fixed rate, which set the operating pace of components in the system unit.
- Each tick is called a *clock cycle*, which affects machine cycle time.
- The faster the clock, the more instructions the CPU can execute per second.

Clock speed.



- This refers to the speed at which a processor executes instructions
- Clock speed is measured in hertz.
- *A hertz is one cycle or tick per second. A Megahertz (MHz) equates to one million ticks of the system clock per second.*
- Processor's speed is sometimes measured according to the number of MIPS (millions of instructions per second) it can process.

COMPUTER SPECIFICATIONS



- Computer specifications refers to the system properties of the computer. These include hardware, software, communication details of the computer.
- They include:
 - PROCESSOR SPEED
 - MEMORY (RAM
 - OPERATING SYSTEM
 - HARD DISK SIZE
 - SIZE OF DISPLAY
 - ETHERNET CAPACITY (NETWORK)
 - WIRELESS ADAPTOR, BLUETOOTH, 4GLTE, 3G

d) Memory (internal/primary storage)



- While performing a processing operation, a processor needs a place to temporarily store instructions to be executed and the data to be used with those instructions.
- The CPU cannot process data on an input device or disk directly; the data must first be available in memory.

d) Memory (internal/primary storage)



- A computer's memory in the system unit is located physically close to the CPU to decrease access time.
- It provides the CPU with a working storage area for program instructions, data and information.
- Memory is also known as primary storage or internal storage.
- Memory usually consists of one or more chips on the motherboard.
- Computer memory is divided into PRIMARY memory and SECONDARY memory.

PRIMARY Vs SECONDARY MEMORY



- Primary memory stores data that the computer is immediately using WHILE secondary memory stores data for future use.
- Primary memory (often) loses its contents when power is switched off; secondary memory retains the contents even when power is switched off.
- Primary memory has limited storage capacity WHILE secondary memory has a lot of capacity measured in Gigabytes and Terabytes
- Examples of Primary memory include RAM, ROM, Cache, CMOS WHILE Secondary memory has Hard Disks, Flash disks , etc

Types of memory:



- The system unit contains two types of memory: volatile and nonvolatile.
- The contents of *volatile memory* are lost when the computer power is turned off.
- *The contents* of nonvolatile memory are not lost when power is turned off.
- RAM is the most common type of volatile memory.
- Examples of nonvolatile memory include ROM, flash memory, and CMOS.
- Below, we discuss these types of memory.

Random Access Memory (RAM)



- ***Random Access Memory (RAM) is the memory chips that are mounted directly on the motherboard or mounted on peripheral***
- ***cards that plug into the motherboard. The RAM chips consist of millions of switches that are sensitive to changes in electric***
- ***current. When the computer is powered on, certain operating system files are loaded from a storage device such as a hard disk***
- ***into RAM. These files remain in RAM as long as the computer is running. As additional programs and data are requested, they are read from storage into RAM. The processor acts upon***
- ***the data while it is in RAM. During the running time, the***
- ***contents of RAM may change as the program is executed.***

**RAM
chip
being
inserte
d into
a
mother
board**



dual inline
memory
module

memory chip

Random Access Memory (RAM)

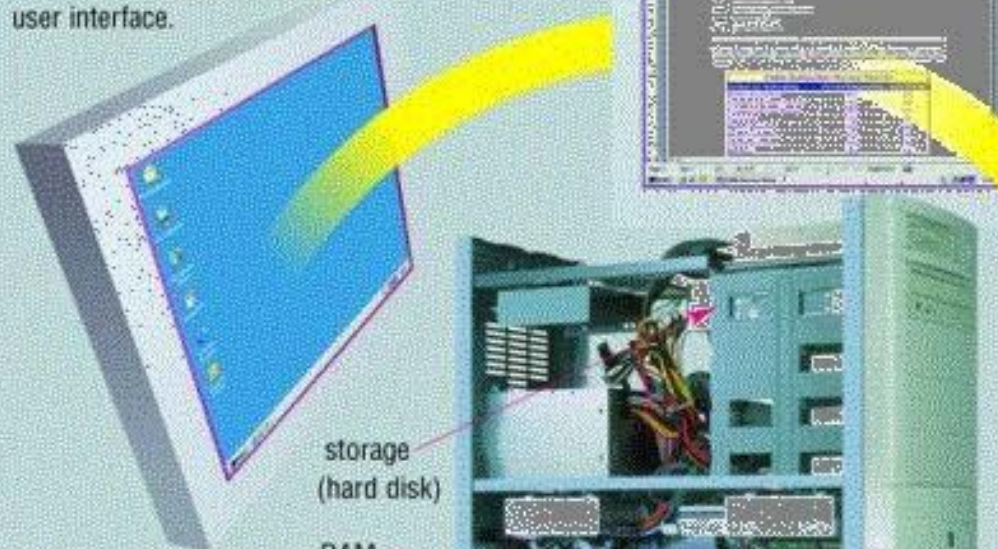


- The amount of RAM a computer requires often depends on the types of applications you plan to use on the computer. A computer only can manipulate data that is in memory. A computer needs a certain amount of memory to store programs, data and information.
- The more RAM a computer has, the faster the computer will respond.
- A software package usually indicates the minimum amount of RAM it requires. RAM in computers purchased today ranges from 128MB, 512MB, 1GB to 64GB.

How program instructions transfer in and out of RAM

Step 1:

When your computer is running, certain operating system files are in RAM. Shown here is the operating system's user interface.



Step 2:

When you start a word processing program such as Word, the program loads into RAM from a hard disk. As you create a document, it is in RAM and displays on your screen.



Step 3:

When you quit Word, RAM may be used to store another program or data. Word is removed from your screen, and the operating system's user interface redisplay.

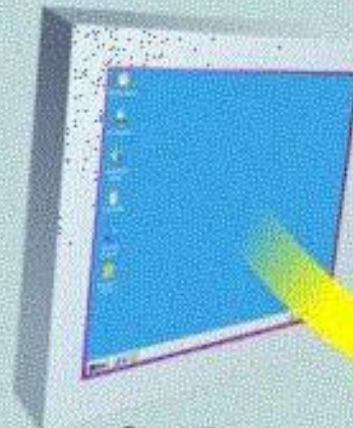
Step 4:

When you start a spreadsheet program such as Excel, the program loads into RAM from a hard disk. As you create a spreadsheet, it is in RAM and displays on your screen.



Step 5:

When you quit Excel, RAM may be used to store another program or data. Excel is removed from your screen and the operating system's user interface redisplay.



Basic types of RAM



- **Dynamic RAM (DRAM)** must be refreshed (or recharged) constantly by the CPU static RAM, and
- **Static RAM (SRAM)** is faster and more reliable than any form of DRAM. The term static refers to the fact that it does not have to be re-energized as often as DRAM.
- **Magneto resistive RAM (MRAM)**, stores data using magnetic charges instead of electrical charges.
- **MRAM** has greater storage capacity, consumes less power, and has faster access times.
- **Virtual RAM (VRAM)**: Modern operating systems can use spare storage space on the hard disk as if it is working memory and this is referred to as Virtual memory or Virtual RAM

Read-only memory (ROM)



- *Read-only memory (ROM) refers to memory chips storing permanent data and instructions. That is, the items stored in ROM*
- *chips cannot be modified—then, the name read-only. ROM is usually nonvolatile. In ROM, the combination of circuit states is*
- *fixed, and therefore its contents are not lost if the power is removed. The data, instructions, or information stored on ROM*
- *chips often are recorded when the chip is manufactured. ROM chips that contain permanently written data, instructions, or*
- *information are called **firmware**. Firmware can be read and used, but cannot be changed by user.*

Basic types of ROM



- *Programmable read-only memory (PROM) is a blank ROM chip on which you can permanently place data and programs.*
- **Once the data and instructions are programmed into PROM chip, the chip functions like a regular ROM and cannot be erased**
- **or changed. A variation of the PROM chip, called *electrically erasable programmable read-only memory (EEPROM) chip*,**
- **allows a programmer to erase the microcode with an electric signal.**

Differences Between RAM and ROM



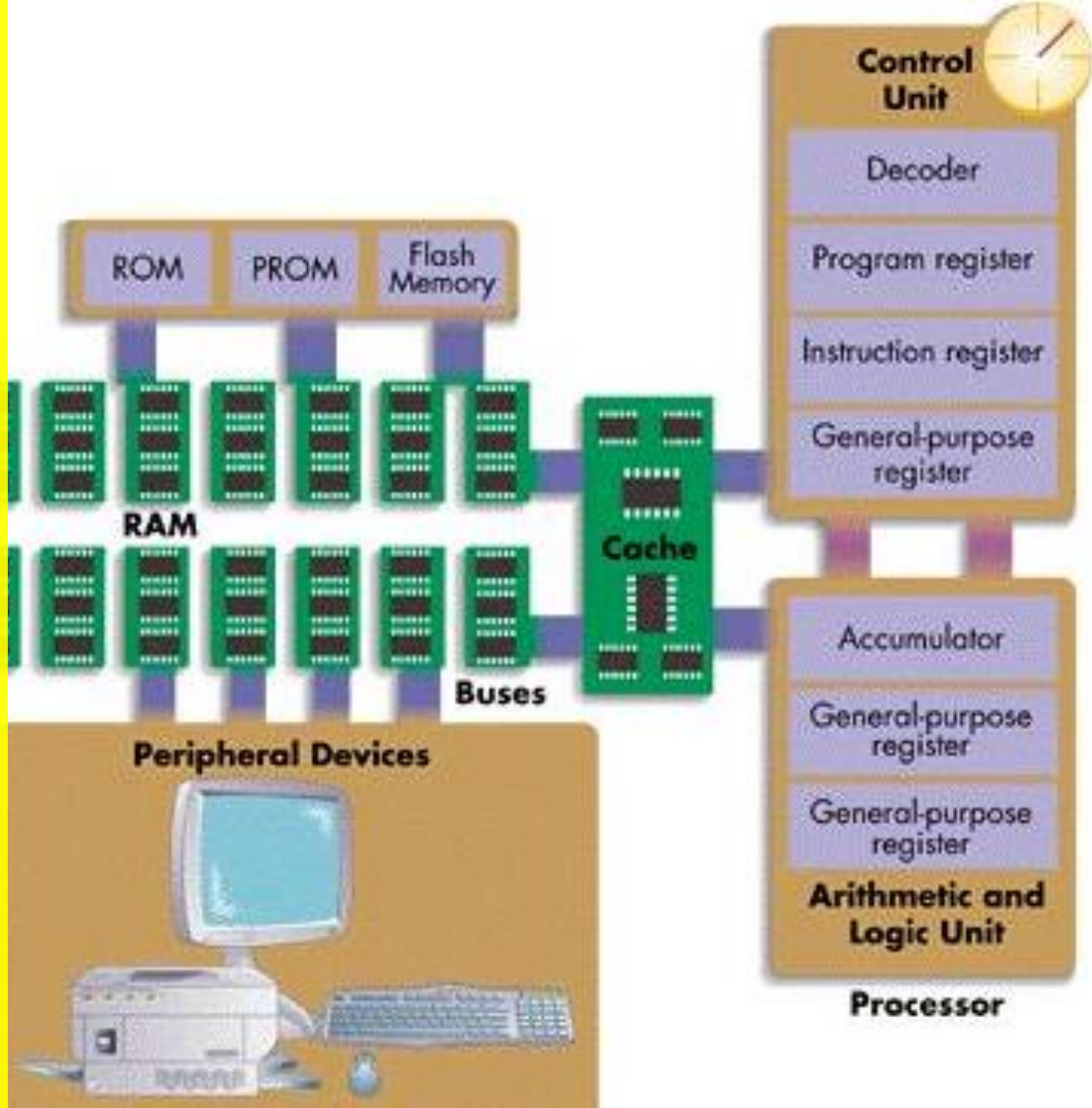
RAM	ROM
1. Volatile, temporally	1.Non Volatile, permanent
2. Contents lost when power goes off	2. Contents remain when power goes off
3. Read and Write	3. Read Only
4. Can be increased	4. Cant be Increased
5. Not installed at Factory	5. Installed at Factory

Memory cache



- A cache is a relatively small block of very fast memory designed for the specific purpose of speeding up the internal transfer of data and software instructions.
- Cache uses internal storage technologies that are much faster than conventional RAM.
- Cache speeds up processing time because it stores frequently used instructions and data.

The processor first checks cache, then RAM for needed data and instructions



Flash memory



- Flash memory is a chip also that keeps its contents when the power is shut off.
- Flash memory can be erased electronically and reprogrammed.
- Most computers use flash memory to hold their startup instructions because it allows the computer easily to update its contents.

CMOS



- **Complementary Metal-Oxide Semiconductor (CMOS) technology provides high speeds and consumes little power.**
- **CMOS technology uses battery power to retain information even when the power to the computer is off.**
- **Battery-backed CMOS memory chips, for example, can keep the calendar, date, and time current even when the computer is off.**

Units of Measuring Computer Memory



- The smallest unit of measuring Computer Memory is a Binary digit (Bit)
- Binary digits are the numbers 1 and 0 which can be represented in a computer by switching voltage on and off.
- Eight little bits make one BYTE.
- The storage capacity of computers (RAM and ROM) and that of auxiliary storage units like disks are generally given in bytes.
- One BYTE stores approximately one character.

More units of Computer Memory:



- Kilobyte (1K or 1 Kb) is $2^{10} = 1024$ bytes. (Approximately 1 thousand bytes)
- Megabyte (Mb) is $2^{10} = 1024$ Kilobytes or 2^{20} bytes, (Approximately 1 million bytes)
- Gigabyte (GB) is $2^{10} = 1024$ Megabytes or 2^{30} bytes, (Approximately 1 billion bytes)
- Terabyte (TB) is $2^{10} = 1024$ Gigabytes or 2^{40} bytes, (Approximately 1 trillion bytes)
- Other higher prefixes are Peta(2^{50}), Exa(2^{60}), Zetta(2^{70}), Yotta(2^{80}), approximately equal to 10^{15} , 10^{18} , 10^{21} , and 10^{24} bytes respectively.
- NB In computing today, the approximation 1024 to 1000 has brought about confusion and many manufactures quote a disk with 1,000,000,000 bytes as 1 GB (10^9) instead of 1,073,741,824 bytes (2^{30})

Examples and Exercises



1. How many bits are required to store the following words?

- a) COMPUTING
- b) BOYS' SCHOOL
- c) 36°C
- d) U.N.E.B

Examples and Exercises



- Q.2 Does a text document with 1,000,000 characters fit onto a 1.4 MB floppy disk?
- Q. 3 Arrange the elements below in terms of their relative size in ascending order:
 - a) Character > Document > Page > Word > Paragraph
 - b) Gigabyte > Kilobyte > Megabyte > Bit > Byte
- Q.4 Convert:
 - (i) 200 kb to bits
 - (ii) 5,120,000 Bytes to Megabytes
 - (iii) 2GB to kb

Answer Q4



- (ii) 5,120,000 Bytes to Megabytes
- Ans: $1\text{MB} = 1000\text{Kb} = 1,024,000\text{bytes}$
- Therefore, 1 byte = MB
- So, 5,120,000 bytes = X5,120,000
- =5MB
- (iii) 2GB to kb Ans: 2,000,000

Computer Data representation & numbering systems



- Humans understand decimal (base ten) just because they have ten counting fingers.



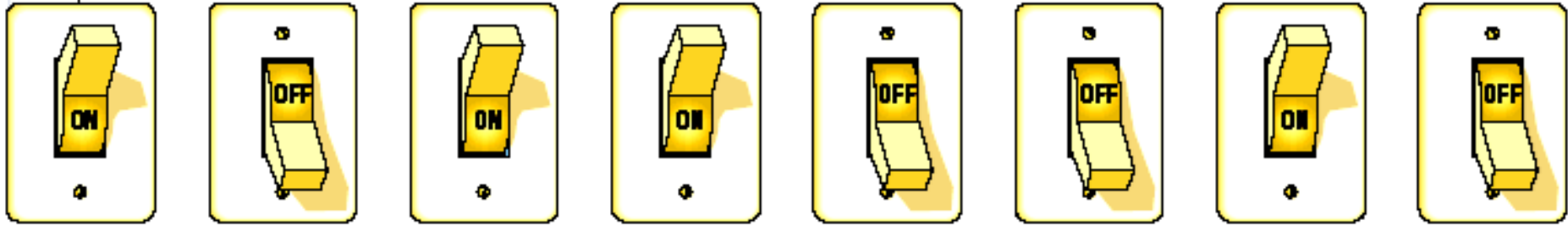
- Digital electronics (computers) understand binary because binary consists of only two digits which correspond to the two power states. 0 representing electrical charge OFF and 1 representing electrical charge ON.
- Octal (base 8) and Hexadecimal (base 16) number systems are used to represent complex binary data in a more compact form.

Binary numbering system



- Binary is a numbering system that is a series of 1s and 0s only.
- The idea of binary was created in the 1600s.
- Binary has been used in nearly everything electronic; from calculators to supercomputers.
- Machine code language is in binary digits.

Binary numbering system



- As an example the following bit pattern represents the word 'HELLO'.
- computer does all that at very high speed during typing and you only see the resulting 'HELLO' on screen.

H E L L O

01000001 00100110 01100101 01100101 00111111

Binary Coding Schemes



- A binary coding scheme is a method used for representing all of the digits, letters, special characters, and control characters available to a digital computer using a combination of bits 0 and 1.
- The off/on 0s and 1s are arranged in such a way that they can be made to represent each character uniquely.
- In a binary number, a digit 0 or 1 is called a bit. For example, 1001 is a 4-bit binary number, and, 11000110 is an 8-bit binary number.
- There are three commonly used binary coding schemes: ASCII, EBCDIC and Unicode

ASCII:



- ASCII is an abbreviation for American Standard Code for Information Interchange.
- It is a character-encoding scheme based on the ordering of the English alphabet.
- ASCII-7 includes coding for $2^7 = 128$ characters
- ASCII-8 includes coding for $2^8 = 256$ characters.
- The name ASCII-8 is often used for binary codes that use all values in a full byte (8 binary digits).

EBCDIC



- The Extended Binary Coded Decimal Interchange Code (EBCDIC) uses 8 bits to represent a symbol in the data.
- EBCDIC was devised in the 1960s by IBM .
- EBCDIC allows $2^8 = 256$ combinations of bits.
- 256 unique symbols are represented using EBCDIC code.
- EBCDIC codes are used mainly, mainly on IBM mainframe and midrange computer systems.

Unicode



- Unicode is a universal character encoding standard for the representation of text which also includes symbols in multi-lingual environments.
- Unicode uses 32 bits to represent a symbol in the data.
- Unicode allows $2^{32} = 4164895296$ (~ 4 billion) combinations.
- Unicode codes can uniquely represent any character or symbol present in any language like Chinese, Japanese etc.

Converting from binary to decimal



- a) Multiply each bit of the **binary** number by its corresponding bit-weighting factor .
- b) Sum up all of the products in step (a) to get the decimal number.

- Eg: Covert 1011 binary to Decimal

- Soln: $1011 \text{ binary} = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 +$
 $= 8 + 0 + 2 + 1$
 $= 11$

Converting from binary to decimal



- a) Divide the decimal number by **2**; and record the remainder.
- b) If the quotient is zero, the conversion is complete. Otherwise repeat step (a) using the quotient as the decimal number. The new remainder is the next most significant bit of the **binary** number.

Convert 235 decimal to binary code

B	N	R
2	235	1
2	117	1
2	58	0
2	29	1
2	14	0
2	7	1
2	3	1
2	1	1
2	0	-

So, 235 decimal = 11101011 binary

The octal numbering system



- The octal numeral system is a base 8 numeral system. It uses the numerals 0 through 7.
- At one time, the octal system was used mainly for work with computers. It provided an easier way to work with binary numbers. As computers changed from using 24-bit systems to 32- and 64-bit systems, hexadecimal replaced octal for most uses.
- The octal numeral system uses a three-bit binary coding. Each digit in an octal numeral is the same as three digits in a binary numeral. The grouping of the binary digits is done from right to left.

Hexadecimal numeral system



- The hexadecimal numeral system, also known as just hex, is a numeral system made up of 16 symbols (base 16).
- It uses the common symbols in the decimal numeral system (0 through 9) and includes six extra symbols. These symbols are characters taken from the English alphabet: A, B, C, D, E and F.
- The hexadecimal system replaced the octal numeral system for much of the work done on computers.

Advantages of using Hex



- Hexadecimal numbers are very compact .
- As computers become more advanced, they tend to use larger groups of bits but they use multiples of 8 (16, 24, 32, 64, etc).
- Hexadecimal makes it easier to write these large binary numbers.
- The hexadecimal, or base 16 number system is important to programmers because it's a shorthand way of writing out and inputting binary. It's simpler and easier because you can work with fewer symbols, or "numbers".
- It is easy to convert from hex to binary and binary to hex.
- Octal is similar to hexadecimal because they are both easily converted to binary. Where octal is equal to three-digit binary, hexadecimal is equal to four-digit binary.



Decimal, Binary, Octal and Hexadecimal Counting Table/ Chart

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

Examples



- 1. What is the octal and hexadecimal equivalent off:
- $111011101_{\text{binary}}$
- 10010101_{binary}
- 45_{decimal}
- (b) What is the binary equivalent for :
 - $1A4C_{\text{hex}}$
 - 4553_{oct}