Lecture 1 Part 2
Central Processing Unit (CPU)

- Components of CPU
- Data Processing in CPU
- Determining processor Speed

The Central processing Unit

- The central processing unit (CPU): The heart and brain of the computer. It receives data input, processes information and executes instructions.

- It is the center of all processing activities. It is here that all processing is controlled, all data are manipulated, arithmetic computations are performed and logical comparisons are made.

  - System Unit: The hardware unit that houses a computer's processor, memory chips, ports, and add-in boards.

CPU components

- In large computers such as super computers and mainframe computers, processing tasks may be handled by multiple processing chips.
- In the average microcomputer, the entire CPU is a single unit, called a microprocessor.
- Regardless of its construction, **every CPU has at least two basic parts:**

1. The Control Unit
2. The arithmetic logic unit

Control Unit

- ***The Control Unit*** regulates the computer operations much as a "traffic cop" would. Its main functions are:
  - select and interpret instructions and to send appropriate signals to other units in the computer for their execution.
  - direct the flow of data through the CPU, and to and from other devices.
  - control, supervise, and oversees all the activities of a computer and monitors the execution of any program processed.
- The control unit can execute only one instruction at a time, but it can execute instructions so quickly (millions per second) that it can appear to do many different things simultaneously.

Arithmetic/Logic Unit

- The ***arithmetic/logic unit*** (ALU) performs the four basic arithmetic operations of addition, subtraction, multiplication and division as well as the logical operations of the comparison between two pieces of data i.e. Greater Than (>), Less Than (<), Equal To (=)

- All computer applications - from weather predictions to word processing are achieved through these five simple operations.

- The ALU operations are performed sequentially (one after another), based on instructions from the control unit.

Primary Storage

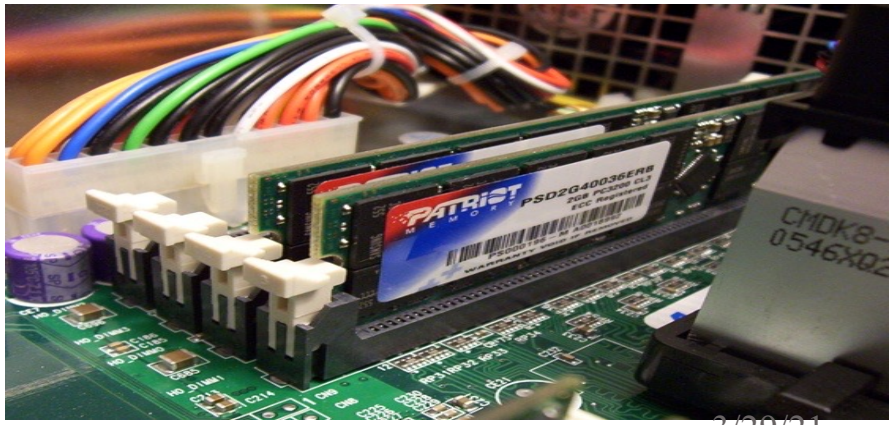
- Primary storage or main memory (RAM) stores data and program statements for the CPU. It has four basic purposes;

  - To store data that have been input until they are transferred to the arithmetic/logic unit for processing.
  - To store data and results during intermediate stages of processing.
  - To hold data after processing until they are transferred to an output device.
  - To hold program statements or instructions received from input devices and from secondary storage.

Primary Storage cont'd

- The larger the memory area, the larger the programs that can be stored and executed.

- In the earlier days, it was common to find personal computers with 4MB of RAM but as multi media (graphics, animation and video), becomes common in the market place, personal computers require high capacity of RAM i.e 128MB, *256MB, 512MB, 1GB, 3GB, ITB etc*



The processing sequence - Machine cycle

- The CPU follows a set of steps-called a ***machine cycle*** for each instruction it carries out.

- By using a technique called pipelining, many CPUs can process more than one instruction at a time.

- *The machine cycle includes two smaller cycles*:
  - *The instruction cycle*
  - *The execution cycle.*

Instruction cycle

- *Fetching:* Before the CPU can execute an instruction, the control unit must retrieve (or "fetch") a command or data from the computers memory.

- *Decoding:* Before a command can be executed, the control unit must break down/interpret/translate the instruction into a form that the CPU can understand.
  - All required data = fetched from main memory & put in data registers

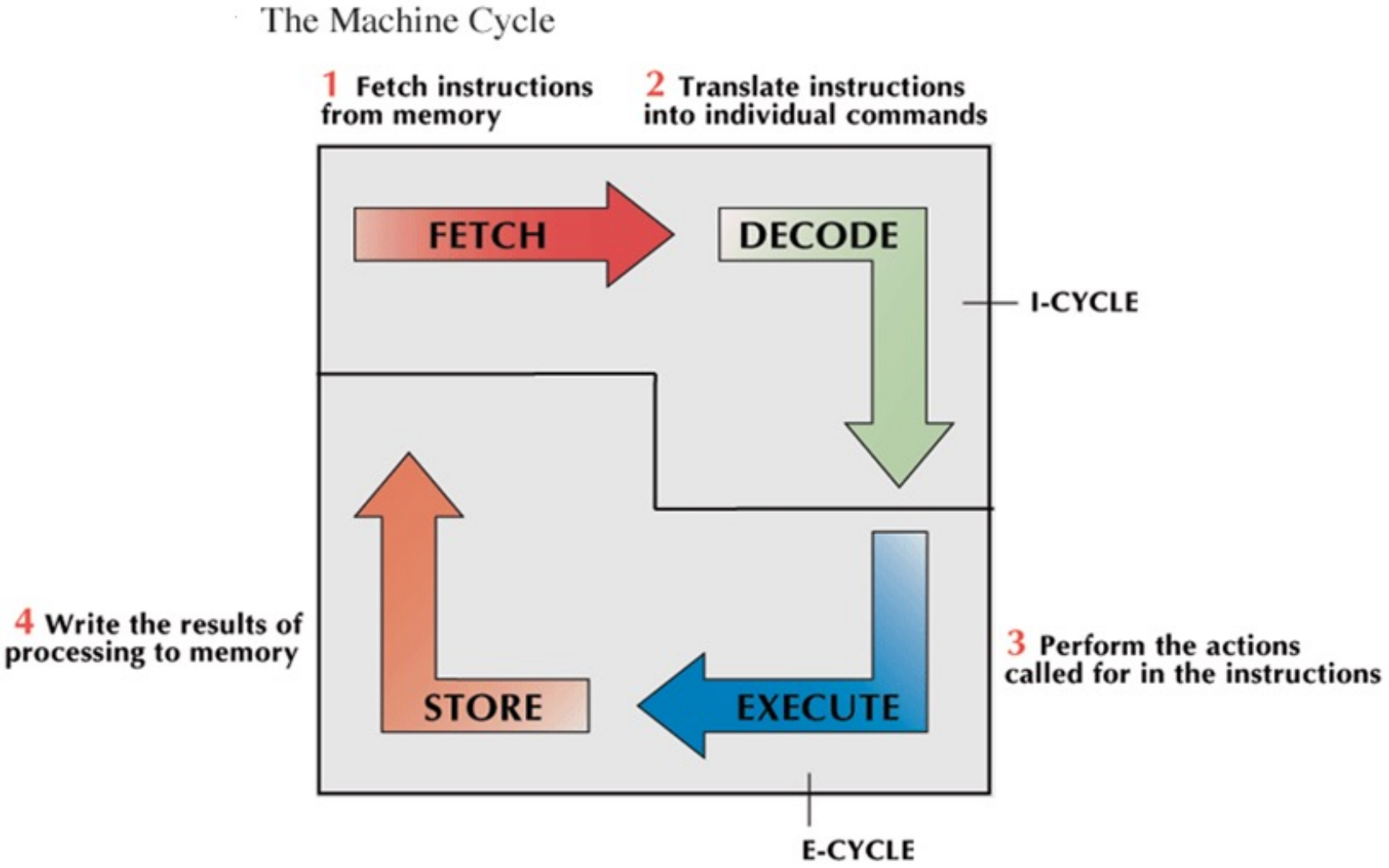
Execution cycle

- *Execution cycle.* The data is manipulated (worked on) by the computer.

- The results of the manipulations are *stored memory.*

- After the execution cycle, the process begins the next instruction. This process continues until the last instruction of the program has been executed.

The Machine Cycle cont'd



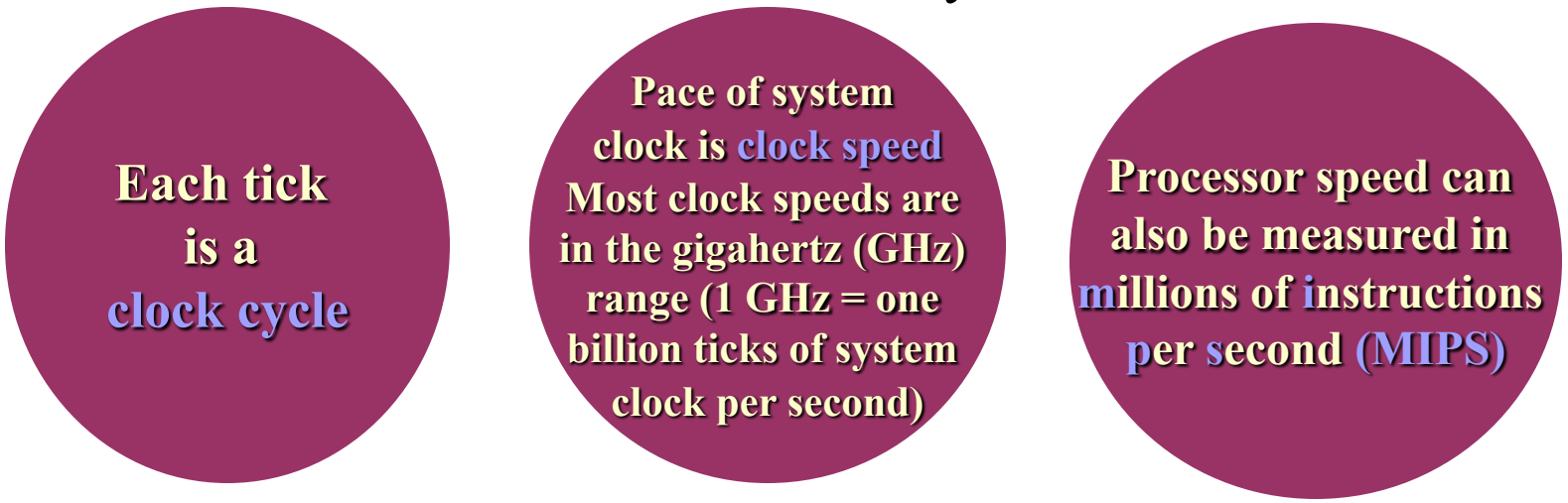
Processor Speed

Determining Processor Speed

- *5 elements:*
  - System Clock
  - Bus Width
  - Cache memory
  - registers
  - Available Memory (Internal Memory)

System Clock

- ***System clock*** is a component that provides the timing for all processor operations. It is located within the control unit.
- A single "tick" of the clock is the time required to turn a transistor off and back on. This is called a clock cycle.



If a computer has a clock speed of 300 MHz, then its system clock "ticks" 300 million times every second.

Clock speed has a tremendous impact on CPU performance. A CPU operating at 300MHz can process data nearly twice as fast as the same one operating at 166MHz

Bus Width

- ***A bus*** is a path between the components of a computer.
- There are two main buses in a computer: ***the internal (or system bus)*** **and the** ***external or (expansion) bus.***
  - The system bus resides on the motherboard and connects the CPU to other devices that resides on the motherboard.
  - An expansion bus connects external devices, such as keyboard, mouse, modem, printer, etc to the CPU.
  - The system bus has two parts: the data bus and the address bus.

Bus cont'd…

- The ***Data bus*** is an electrical path composed of parallel wires that connects the CPU, memory, and the other hardware devices on the motherboard.
- ***The address bus*** is a set of wires similar to the data bus. The address bus connects CPU to memory and carries only memory address
  - Requests for data are sent from the CPU to RAM along the address bus. The requests consist of a memory address.
  - The data comes back to the CPU via the data bus.
- The number of wires in the bus affects the speed at which data can travel between hardware components.
- Because each wire can transfer ***1 bit of data*** at a time, an 8-wire bus can move 8 bits at a time which is a full byte.

Registers

- **Registers are** high speed memory locations built directly into the ALU and used to hold instructions and data currently being processed.
- The size of the registers (also called word size) determines the amount of data with which the computer can work at any given time.
- The bigger the word size, the more quickly the computer can process a set of data.
- Today, most PCs have 32-bit registers, meaning the CPU can process four bytes of data at one time. Register sizes are rapidly growing to 64 bits.

Cache memory

- Moving data between RAM and the CPU's registers is one of the most time consuming operations a CPU must perform.
- A partial solution to this problem is to include a cache memory in the CPU.
- Cache memory is similar to RAM, except that it is extremely fast compared to normal memory and it is used in a different way.
- When a program is running and the CPU needs to read data from RAM, the CPU checks first to see whether the data is in cache memory.
- If the data is not there, the CPU reads it from RAM into its registers but also keeps a coy of the data in cache memory.

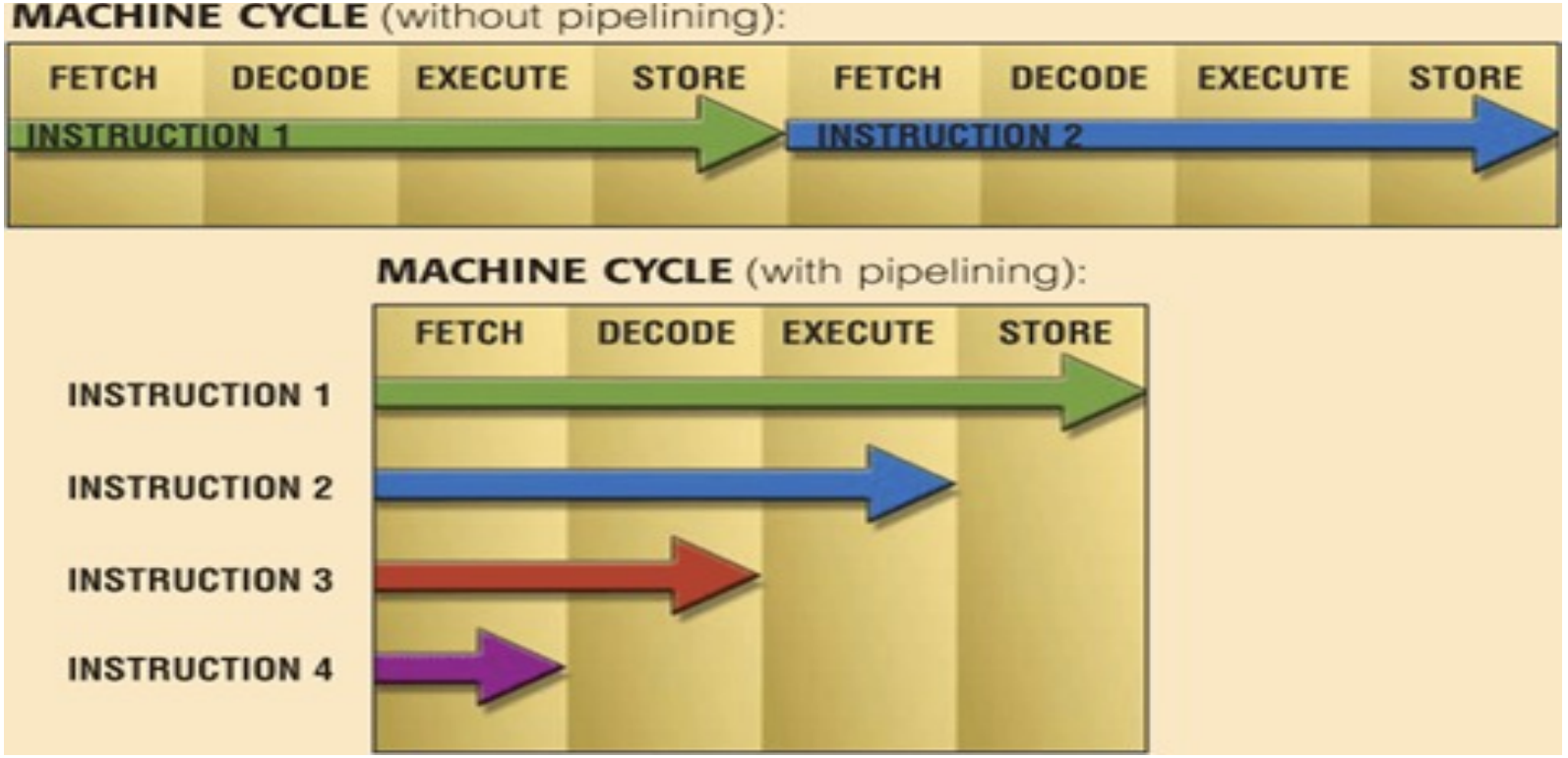
Cache memory

- The next time the CPU needs the same data, it finds it in the cache memory and saves the time needed to load that data from RAM.
- *Therefore, cache memory speeds up processing by storing frequently used data or instructions in its high speed memory.*
- Today, many CPUs have as much as 256KB cache memory built in.
- Cache memory is sometimes described in levels of closeness and accessibility to the microprocessor.

- Cache built into the CPU itself is referred to as *Level 1 (L1)* cache. Cache that resides on a the motherboard is also called *Level 2 (L2)* cache.

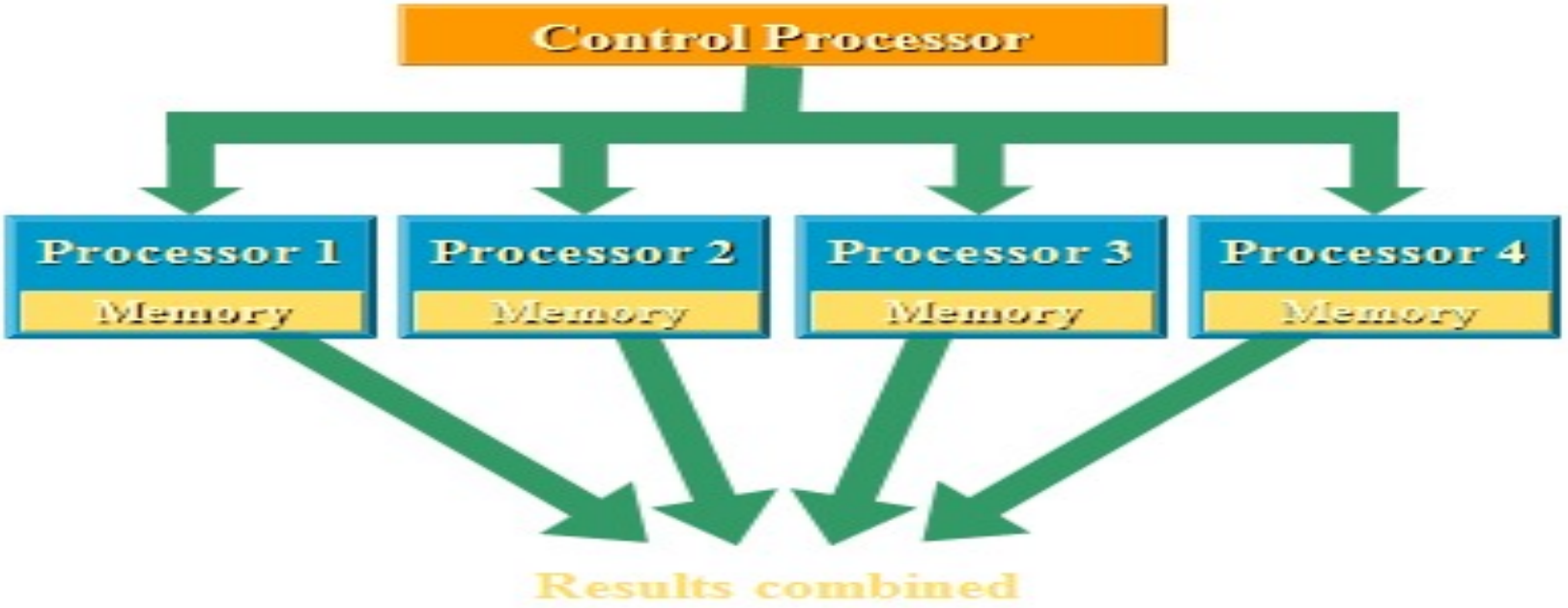
Pipelining

- ***Pipelining*** CPU begins fetching second instruction before completing machine cycle for first instruction
- Results in faster processing



Parallel processing

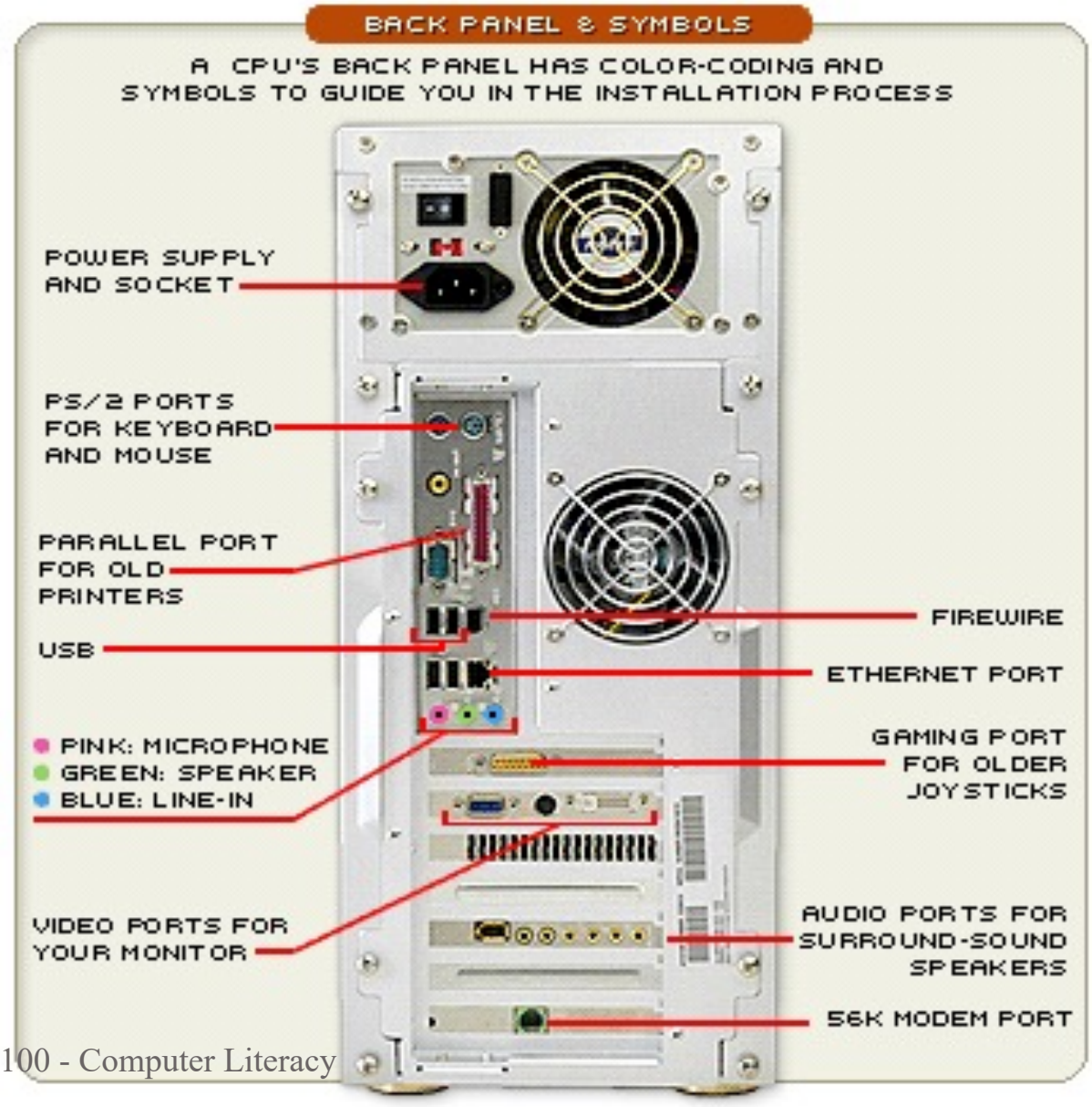
- ***Parallel Processing***: Using multiple processors simultaneously to execute a program faster
- Requires special software to divide problem and bring results together.



Ports

- *Port:* A connector through which input/output devices can be plugged into the computer.

Ports cont'd


BACK PANEL & SYMBOLS
A CPU'S BACK PANEL HAS COLOR-CODING AND SYMBOLS TO GUIDE YOU IN THE INSTALLATION PROCESS
POWER SUPPLY AND SOCKET
PS/2 PORTS FOR KEYBOARD AND MOUSE
PARALLEL PORT FOR OLD PRINTERS
USB
PINK: MICROPHONE
GREEN: SPEAKER
BLUE: LINE-IN
VIDEO PORTS FOR YOUR MONITOR
FIREWIRE
ETHERNET PORT
GAMING PORT FOR OLDER JOYSTICKS
AUDIO PORTS FOR SURROUND-SOUND SPEAKERS
56K MODEM PORT

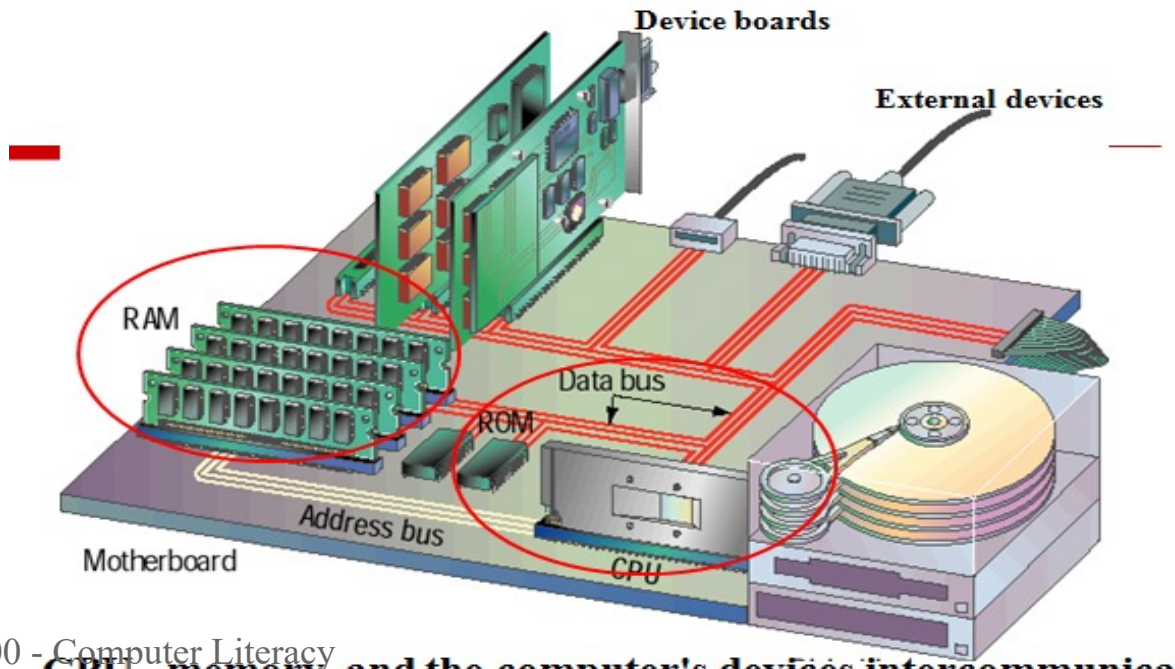
Universal Serial Bus

- *Universal Serial Bus (USB):* A general purpose port that can connect up to 128 devices, and also hot swappable, meaning that devices can be plugged in or unplugged without having to shut down or reboot the system.

- **Plug and Play:** The ability to install devices into a computer when the computer itself makes any necessary internal adjustments.

Note

- Processing takes place in the PC's central processing unit (CPU). The system's memory plays a crucial role in processing data. Both the CPU and memory are attached to the system's motherboard, which connects all the computer's devices together, enabling them to intercommunicate.



CPU , memory and the computer's devices intercommunicate.

Discussion questions

1. Discuss the different types of Random Access Memory (RAM)