Topic 1B: Install and Configure Motherboards:

All computer software and data are handled using **binary code**, which is just a series of **1s and 0s**. The **CPU (Central Processing Unit)** is like the **brain** of the computer that processes instructions and runs programs. RAM is the **workspace** of the CPU. It temporarily stores the instructions and data the CPU is currently using. RAM only works while the computer is on. When you turn it off, everything in RAM is erased.

Mass storage includes devices like **hard drive (HDD)** or **solid-state drive (SSD)**, which store data permanently even when the computer is turned off. Mass storage is slower than RAM but keeps your files safe.

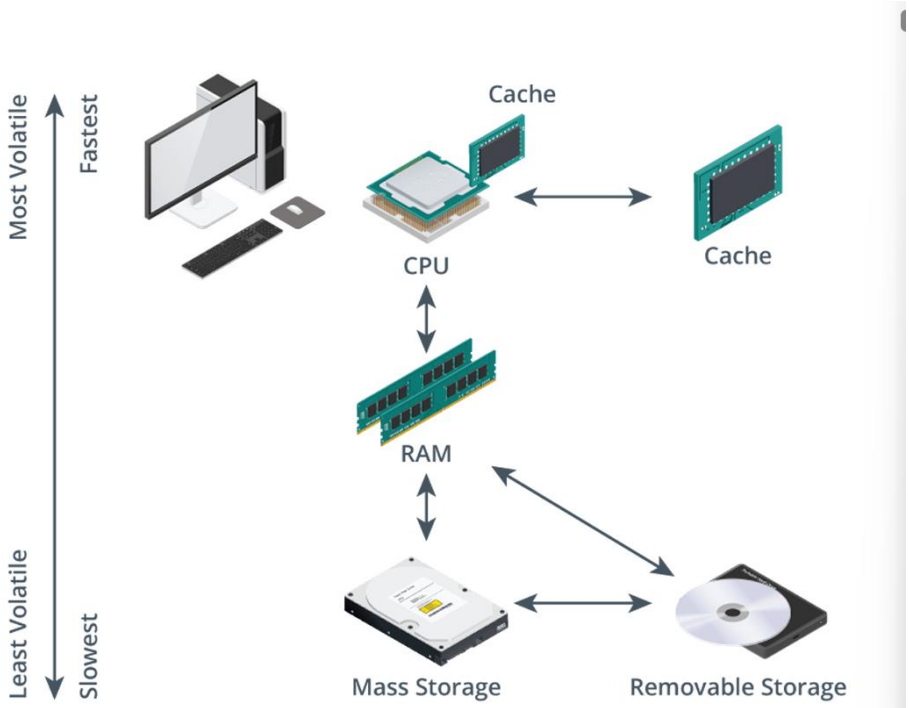
Speed vs. Persistence:

- **CPU, Cache, and RAM** are **fast but volatile** (temporary).
- **Mass storage** (hard drives or SSDs) is **slower but permanent**.

The motherboard connects all components (CPU, RAM, storage, etc.) through **bus interfaces**. These are like **roads** that allow data to travel between different parts of the computer. The motherboard has a **system clock** that keeps everything synchronized, like a conductor leading an orchestra. The speed of the clock is measured in **megahertz (MHz)** or **gigahertz (GHz)**. Faster clock speeds mean faster processing.

Motherboard Design and Compatibility:

- **Motherboard Types:**
  - Different motherboards support specific CPUs, so choosing the right combination is important.
- **Manufacturers:**
  - Popular motherboard brands include **ASUS**, **Gigabyte**, **MSI**, and **Intel**.
- **CPU Manufacturers:**
  - The two main CPU makers are **Intel** and **AMD**.



CPU, cache, and RAM are fast but volatile. Mass storage and removable storage devices provide slower but permanent data retrieval. (Image ©123RF.com)

ELECTRICAL SAFETY AND ESD:

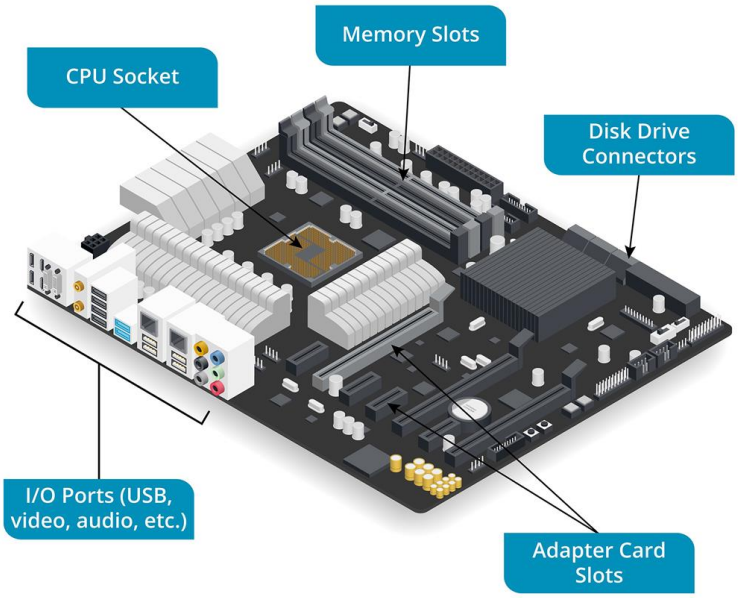
Always disconnect the PC from power and hold the power button to discharge any remaining charge before opening the case. Avoid disassembling non-repairable components like the power supply.

Electrostatic Discharge (ESD)

Protect sensitive components like the CPU, RAM, and motherboard by using anti-ESD tools (e.g., wrist strap) and handling parts by their edges to prevent static discharge damage.

ESD wrist strap on ESD mat. (Image by Audrius Merfeldas © 123RF.com)

MOTHERBOARD CPU AND SYSTEM MEMORY CONNECTORS:



Motherboard connectors. (Image © 123RF.com)

CPU Sockets:

Most CPU are manufactured by Intel (LGA) and AMD(PGA). When the CPU is installed, it is covered by **heat sink** and **fan**. The function of CPU is supported by motherboard's chipset. It includes **Northbridge and Southbridge. Northbridge** handles communication between CPU and high speed memory controllers like RAM, high graphics card, etc. **Southbridge** handles communication between CPU and other lower speed memory controllers. Chipset are **directly integrated into the motherboard** and cannot be **replaced.** In fact, chipset controls the entire data flow between CPU and other components. And also **Chipset** determines the type of processor, maximum RAM supported, and other I/O ports such as video, sound, and networking.

RAM:

RAM is normally packaged as **Dual Inline Memory Module (DIMM)** fitted to the motherboard slots. It is closely located to the CPU to support more speed.

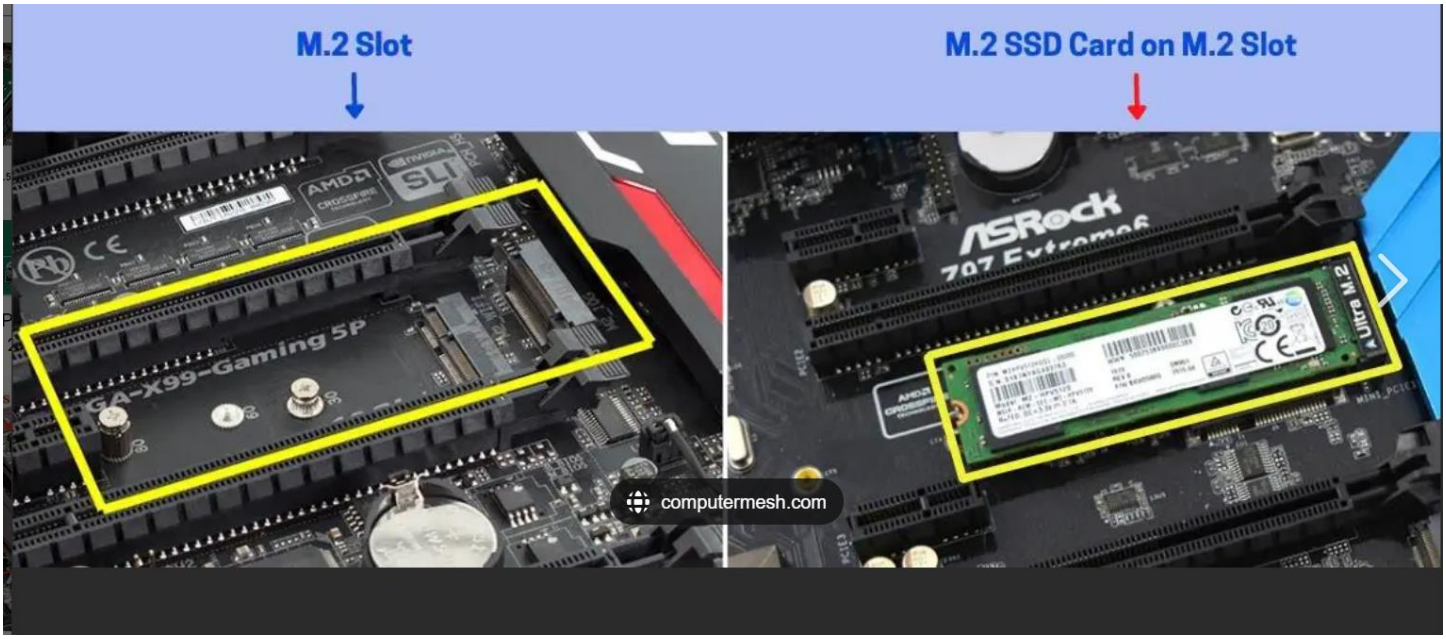
MOTHERBOARD STORAGE CONNECTORS

Serial Advanced Technology Attachment Interface

SATA ports are used to connect one or more fixed storage devices such as **SSDs** and **HDDs**. It can also be used to connect **tape drives** and **optical drives (DVD/Blu-ray).** Only **one device** can connect to one SATA port.

M.2 Interface:

It is an internal slot on the motherboard for compact storage devices. While the latest **SATA's** speed is **6Gbps**, the **M.2** supports upto **64Gbps**. And it is also small, and compact and does not need any cables. It is used in modern SATA M.2 SSDs. Lengths can be like **(42mm, 60mm, 80mm, or 110m).**



External SATA (eSATA):

Used to attach external HDDs or SDDs mostly. The cable is **2m (78inch) long.** We cannot use Internal SATA cable for connecting to an external **eSATA port.** The main drawback of eSATA compared to USB or Thunderbolt external drives is that power is not supplied over the cable. This will not be an issue for **3.5 inches drives** which **require** a separate **power supply,** but it will be an issue for **2.5-inch** portable drives.

MOTHERBOARD ADAPTER CONNECTORS:

Peripheral Component Interconnect Express Interface (PCIe):

It is used to connect most modern expansion cards like graphics cards, sound cards, and network cards to the motherboard. It's designed for **fast, point-to-point connections**. It means, each device connected via PCIe has its own dedicated **link** (connection) to the motherboard. **More lanes = faster performance.** PCIe slots/cards typically come in sizes like **x1, x4, x8, and x16,** indicating how many lanes they use.
Example:

- A **x16 slot** has 16 lanes and is commonly used for high-performance graphics cards.
- A **x1 slot** has 1 lane and is used for simpler devices like network cards.

Transfer rates are often calculated in gigatransfers per second (GT/s).

Slot Compatibility (Up-Plugging and Down-Plugging) in PCIe slots:

1. **Up-Plugging:**
    - If a card uses fewer lanes (e.g., **x8**), it can fit into a larger slot (e.g., **x16**). It will work, but it will only use **x8 lanes**.
2. **Down-Plugging:**
    - A card with more lanes (e.g., **x16**) can fit into a smaller slot (e.g., **x8**) **if the case allows it**, but it will be limited to the smaller slot's lanes.
3. **Labels on the Motherboard:**
    - Slots may look larger but don't always support all lanes physically present. For example:
        - A slot labeled **x16 @ x8** looks like a 16-lane slot but operates at **x8 speed**.

Backward Compatibility:

- PCIe is **backward-compatible**, meaning:
    - A **PCIe 2.0 card** can work in a **PCIe 4.0 slot**.
    - The system will run at the **lowest version's speed**.

Power Supply for PCIe slots:
Graphics cards can get power directly from the PCIe slot:

- Up to **75W** from a dedicated graphics slot.
- Additional power (up to 75W more) can be supplied via a **PCIe power connector** attached to the graphics card.

Imagine you're upgrading your computer with a **graphics card**:

- You buy a **PCIe 4.0 x16 graphics card**.
- If your motherboard supports PCIe 4.0 x16, the card will run at full speed (63.015 GB/s).
- If your motherboard is older (e.g., PCIe 2.0), the card will still work but at **PCIe 2.0 speeds**.

Version	GT/s (Gigatransfers/second)	GB/s for x1	GB/s for x16
PCIe 2	5	0.5	8
PCIe 3	8	0.985	15.754
PCIe 4	16	1.969	31.508
PCIe 5	32	3.938	63.015

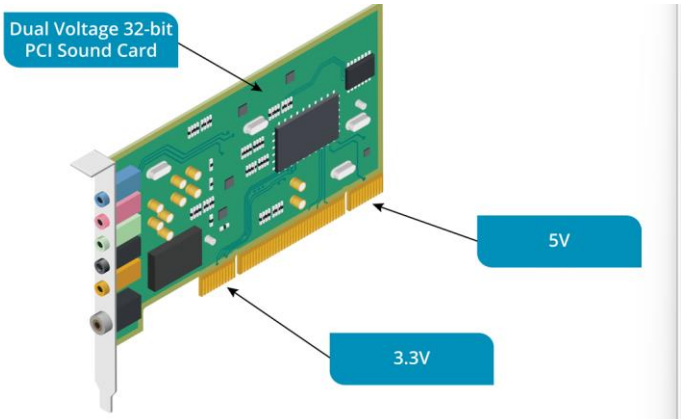
To remember the speed, just see in each column, the **new speed is almost double the previous one.**

Peripheral Component Interconnect Interface (PCI) slots: (uses 5Voltage signaling)

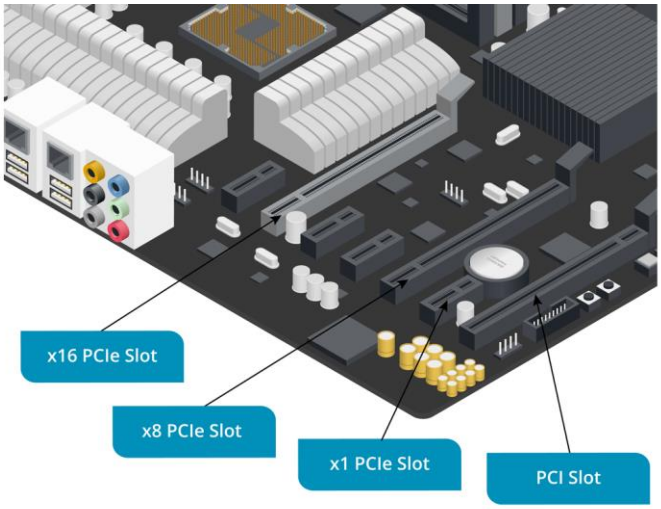
PCI (Peripheral Component Interconnect) is an **older expansion bus** used in computers to connect hardware components like sound cards, network cards, and graphics cards. It has been **replaced by PCIe (PCI Express)**, but some motherboards still include PCI slots to support older devices (legacy hardware). PCI uses **parallel communication**, meaning data is sent across multiple wires at the same time. This method is less efficient compared to PCIe, which uses **serial communication** (faster and more modern).
ransfer Rate:

- Most PCI cards are **32-bit** and operate at **33.3 MHz**.
- Data transfer rate calculation:
    - **32 bits ÷ 8 = 4 bytes.**
    - **4 bytes × 33.3 MHz = 133 MBps.** Much slower compared to to PCIe. PCIe in **GB/s.**

In PCI slots as well, there is **Keying (physical notches)** to prevent from incompatible cards being inserted.



32-bit PCI sound card with dual voltage. (Image ©123RF.com)



One trick to remember between x16, x8, x1 and PCI slot is the distance from the CPU. Since x16 requires faster data transfer, comparatively it is located near the CPU socket. The **closer the PCIe slot to the CPU**, the **higher the bandwidth and faster the data transfer**, so x16 slots are typically nearest to the CPU socket.

MOTHERBOARD FORM FACTORS:

The form factor describes its shape, layout, and the type of the case and power supply that can be used, plus the number of adapter cards that can be used.

ATX Form Factor:

Stands for Advanced Technology Extended (ATX) is the standard form factor for PC motherboards and cases. Full size ATX boards are **12 inches wide x 9.6 inches (305mm x 244mm)** long. And can support upto **7** expansion slots.

Micro-ATX (mATX) size is **9.6 inch (244mm x 244mm) and** of **square** size. Most **mATX** can be mounted in ATX cases also.

Information Technology eXtended Form Factor (ITX) Form factor:

ITX is a type of motherboard form factor (size and design) made for **small form factor (SFF)** PCs. It was created to build compact computers that are smaller than regular desktop PCs, like home PCs, mini-servers, or portable systems. Mini-ITX boards are **6.7 inches by 6.7 inches (170 mm x 170 mm)**, making them small and ideal for

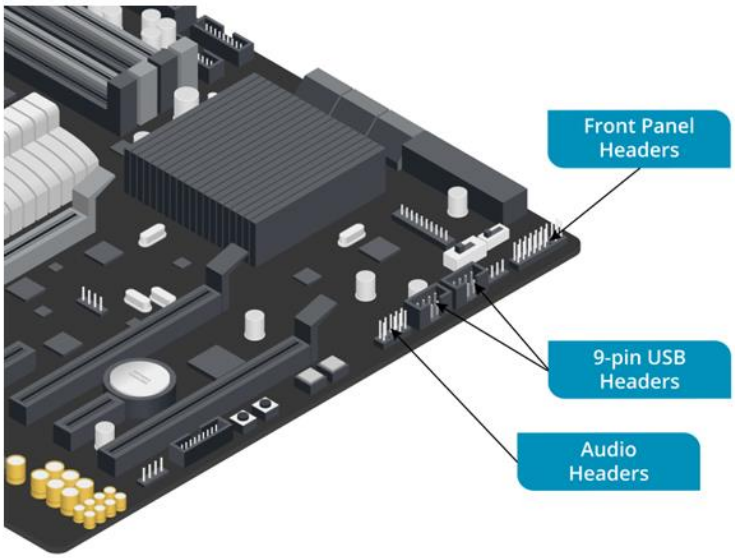
compact PC cases. These motherboards usually have **one expansion slot**, limiting the number of additional cards (e.g., graphics cards or network cards) you can add. Can be mounted with **ATX cases** for flexibility.

There are other versions of the ITX form factor as well.

1. **Nano-ITX:**
    - Smaller than Mini-ITX, used for embedded systems (specialized devices like routers or IoT devices).
2. **Pico-ITX:**
    - Even smaller, for very compact or portable devices.
3. **Mobile-ITX:**
    - The smallest version, mainly used for mobile and handheld systems.

Note: These smaller ITX boards are not used for standard desktop PCs but for **specialized devices**.

MOTHERBOARD HEADERS AND POWER CONNECTORS:



Motherboard front panel, USB, and audio headers. (Image ©123RF.com)

Headers:

Headers are **small pins on the motherboard** that connect the case's components (like power buttons, lights, and USB ports) to the motherboard. There are different types of headers.

- **Power Button Header:** Connect the case's power button to the motherboard.
- **Drive (HDD) Activity Lights:** Blinks when HDD is accessed.
- **Audio Ports Header:** Connects headphone/microphone jacks on the case to motherboard for sound I/O.
- **USB Ports Header:** There is two USB port headers. One is **USB 2.0, 9 pins (8 connector + 1 for keying)** and another is **USB 3.0, 20 pins in the format 2x10.**

Power Connectors:

1. **P1 Motherboard Power Connector (Main Power):**
    - This is the **main power connector** from the power supply to the motherboard.
    - It's a **24-pin block** (arranged as **2 rows of 12 pins**).
    - Provides power to the motherboard and connected components.

---

2. **Fan Connectors:**

- These are used to power and control **fans** in your PC, like the CPU fan, case fans, or other cooling components.

Types of Fan Connectors:

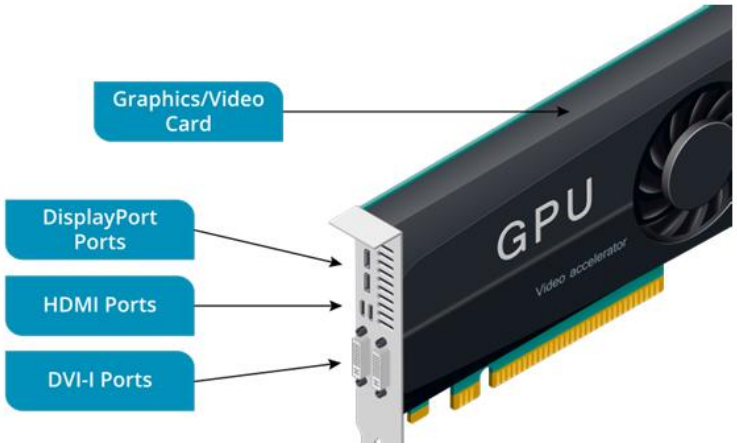
2. **3-Pin Fan Connectors:**
   - Use three wires:
     - **Power (red)**: Supplies electricity to the fan.
     - **Ground (black)**: Provides the return path for current.
     - **Tachometer (yellow)**: Monitors the fan's speed.
   - Fan speed is controlled by **varying the voltage**.
3. **4-Pin Fan Connectors:**
   - Add a fourth wire:
     - **PWM (blue)**: Provides precise fan-speed control through **pulse-width modulation**.
   - This allows the system to dynamically adjust fan speed based on temperature.

Compatibility:

- **3-Pin Fans on 4-Pin Headers:**
  - Will work, but the fan speed may not be adjustable or might require special configuration.
- **4-Pin Fans on 3-Pin Headers:**
  - Will work, but the fan won't use PWM and will run at a fixed speed.

VIDEO CARDS AND CAPTURE CARDS:

Expansion cards are add-ons that give a computer extra functions or ports not built into the motherboard. They fit into **PCIe or PCI slots** on the motherboard. Examples: **Video cards, sound cards, capture cards, network cards.**



Video Cards (Graphics Adapters)

A **video card** generates the signal that powers your monitor or projector. It's essential for tasks like gaming, CAD (computer-aided design), or digital art. Here's a breakdown of its features:

1. Graphics Processing Unit (GPU):

- The **GPU** is a microprocessor designed to handle the creation of 2D and 3D images and effects on the screen.
- Performance is measured by:
  - **Frame rate**: How smoothly images are displayed during games or applications.
  - Support for advanced effects like textures and lighting.

2. Graphics Memory:

- Video cards use **GDDR RAM** (Graphics Double Data Rate similar to DDR used in system memory) for faster processing of 3D effects.

- **High-end cards**: Up to **12 GB GDDR RAM** (for advanced tasks like 3D rendering or 4K gaming).
- **Mid-range cards**: Typically **4–6 GB GDDR RAM** (suitable for most tasks).
- **Low-end cards**: Use **shared memory** (borrow system RAM instead of having dedicated memory).

3. Video Ports:

- The number and type of **video connectors** on the card determine what displays you can connect:
  - Examples: **HDMI, DisplayPort, Thunderbolt.**

4. Installation:

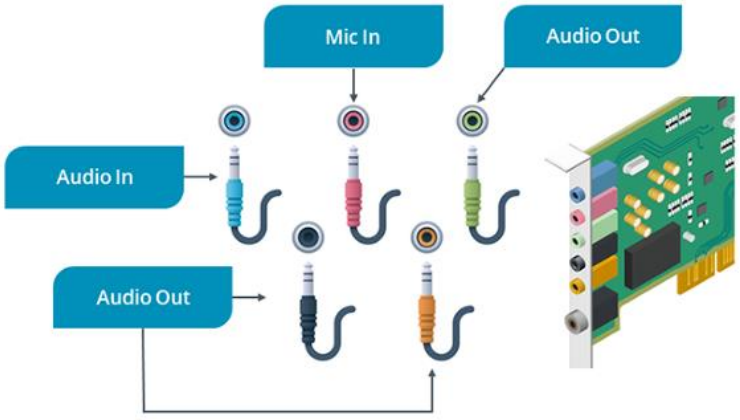
- Most video cards use a **PCIe x16 slot** on the motherboard.
- The slot has a **retaining latch** to hold the card securely.
- **Dual cards**: Some setups use multiple video cards for increased performance.

Capture Cards

- **Capture cards** allow a computer to record video from external sources, like cameras or gaming consoles.
- Used for:
  - **Streaming gameplay.**
  - Recording content for YouTube or other platforms.
- Installed in the same way as a video card, using a PCIe slot.

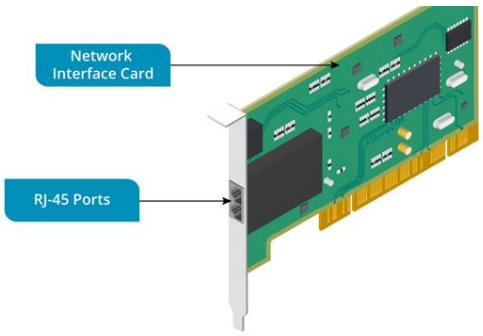
Sound Cards:

Sound cards can input and output sounds from the computer. Most audio jacks are 3.5mm (1/8 inch) mono or stereo jacks. These are also referred to as phone plugs, or mini tip, ring, sleeve (TRS) connectors. Basic sound chips can be found in chipset but for better performance, additional cards can be used in PCI or PCIe. When we use the audio recording functionality of the PC which is given by the manufacturer, it often faces disturbance from internal running components. Hence, we use additional sound cards for better performance.



Audio jacks on a sound card. (Image ©123RF.com)

Network Interface Cards:



RJ45 ports on a Network Interface Card (NIC). (Image ©123RF.com)

Most computers have an Ethernet network adapter already built in as the part of the **motherboard chipset.** When there is need of additional, we install **Network Interface Card** additionally. It provides multiple ports. These ports can be bounded into a single higher bandwidth link. Wi-Fi adapters are developed to different 802.11 standards.

Answer the following questions:

1. **What type of motherboard socket is used to install system memory?**
    - **DIMM (Dual Inline Memory Module) socket** is used to install system memory on a desktop motherboard.
    - **SODIMM (Small Outline DIMM)** is used for laptops.

---

2. **How many storage devices can be attached to a single SATA port?**
    - **One storage device** (like a hard drive or SSD) can be attached to a single SATA port.

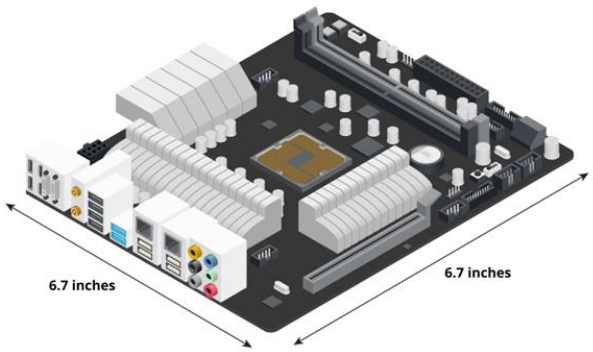
---

3. **What is the bandwidth of a PCIe v2.0 x16 graphics adapter?**
    - The bandwidth of a **PCIe v2.0 x16** graphics adapter is **8 GB/s**.

---

4. **You have a x8 PCIe storage adapter card—can you fit this in a x16 slot?**
    - **Yes**, you can fit a **x8 PCIe card** into a **x16 slot**. This is called **up-plugging**, and the card will work using **x8 lanes**.

5. **Which type of motherboard is shown in the following image?**



(Image ©123RF.com)

MiniITX