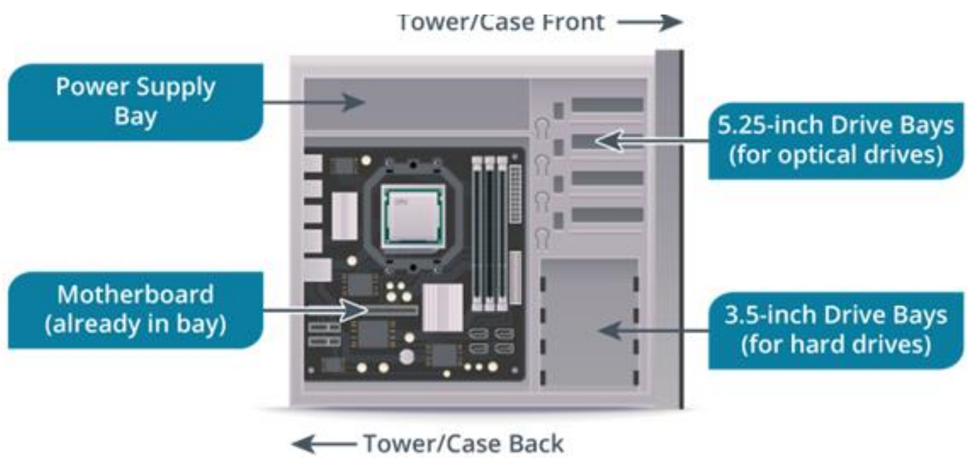
Topic 2B: Select and Install Storage Devices:

Mass Storage Devices:

Mass storage devices store data when the system is powered off and can use **magnetic**, **optical**, or **solid-state** technology. Internal storage devices are called **fixed disks** and fit into drive bays of standard sizes like **5.25-inch**, **3.5-inch**, and **2.5-inch**. Fixed disks are mounted using caddies or rails, and adapter caddies can fit smaller drives into larger bays. **Removable storage** devices, like external hard drives, connect via **USB** or **Thunderbolt** for data transfer and backups. Factors to consider when choosing storage are **reliability (**risk of device failures and data corruption), **performance** (speed for sequential or random data), and **use case** (e.g., OS, backups, or streaming). Popular brands include Seagate, Western Digital, and Samsung.



Solid State Drives (SSDs):

A **Solid-State Drive (SSD)** is a type of storage device used in computers to store data, like documents, photos, and software. It works differently from the older **Hard Disk Drive (HDD)**, which uses spinning disks and a moving arm to read/write data. It uses **flash memory** for faster performance compared to traditional hard disk drives (HDDs). No moving parts, making it more durable and less prone to mechanical failure.

Benefits of SSDs

1. **Speed**: SSDs are much faster, especially when opening files or booting up your computer.
2. **Durability**: Since there are no moving parts, SSDs are less likely to break if you drop your laptop.
3. **Lower Risk of Wear and Tear**: With no moving parts, there's less chance of mechanical failure compared to HDDs.

Downsides of SSDs

1. **Wear from Repeated Use**: Writing data repeatedly on an SSD can wear it out over time.
2. **Performance with Large Files**: If you're dealing with really big files, like movies or games, SSDs might not always perform better than HDDs, especially if they're low-end SSDs.

There are **3** types of SSDs. They are **Single Level Cell, Multi Level Cell, and Triple Level Cell.** Among them the most reliable and expensive is **Single Level Cell.**

There are different **form factors** that are currently in use in SSDs.

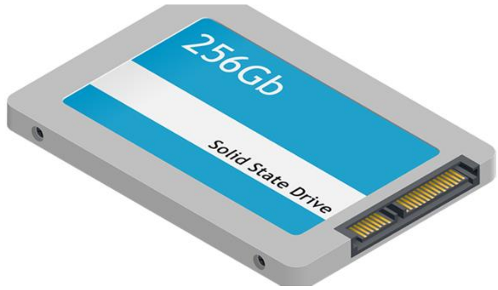
- **2.5-inch SSD**: Fits into most laptops and desktops, connects via **SATA** cable.
- **M.2 SSD**: Small and compact, plugs directly into the motherboard. May use SATA or NVMe.
- **NVMe SSD**: High-speed SSD that connects directly to the PCIe bus for the fastest performance.

They are connected to the motherboard through SATA and NVMe interfaces.

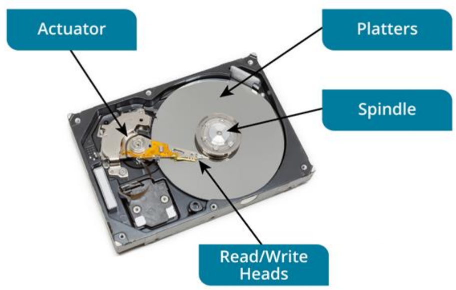
- **SATA (AHCI)**: Used by older SSDs, limited to 600 MBps.
- **NVMe (Non-Volatile Memory Express)**: Used by modern SSDs for speeds up to 6.7 GBps.

Power and Data Connections:

- SATA SSDs need separate power and data cables.
- M.2/NVMe SSDs use a single slot on the motherboard and don't need extra cables.



Hard Disk Drives (HDDs):



Hard Disk Drive (HDD) stores data on spinning metal or glass platters coated with a magnetic material. Data is read and written using **read/write heads** moved by an **actuator arm**. Platters are mounted on a **spindle** and spin at high speeds. Each platter is divided into **tracks**, and tracks contain **sectors** (each holds 512 bytes of data). The layout of tracks and sectors is known as **drive geometry**.

Spin speed of the platters determines how data quickly data is accessed. It is calculated in **RPM** units. The common RPM ratings are: **15000 RPM, 10000 RPM** are high-speed drivers whereas **7,200 or 5,400 RPM** are average drivers.

Access Times is the time it takes for read/write head to locate a track (seek time). It is often affected by **rotational latency** (time to locate sectors). High performance HDDs offers access time below **3ms,** whereas typical drives offers access times around **6ms.**

The internal transfer rates measures how quickly data is read/write from the platter. **15,000 RPM** has rates upto **180MBps** whereas **7,200 RPM** have around **110 MBps**.

The common interfaces that **HDDs** use are **SATA** in most of the HDDs and **SCSI** in enterprise setups.

There are two form factors of HDDs. **3.5** inch HDDs used in most desktop PCs whereas **2.5** inch are used in laptops, and portable external hard disks.
Important: HDDs have **moving parts**, making them more prone to failure from drops or mechanical wear.

REDUNDANT ARRAY OF INDEPENDENT DISKS (RAID):

In the computer, HDDs or SSDs are mainly used for storing user information as well as boot information, right. So, in case, if these drives gets corrupted or failed, then we might lose our all data. So in this particular case, **RAID** technology comes in handy. Whenever we talk about the Redundant array, we talk about the **backup.** So, RAID also means to install multiple drives that often act as a combined drive.

Hence, we can define **RAID is** a technology used to store critical data more securely and efficiently by combining multiple drives into one system. It helps prevent data loss and system crashes that can occur if a drive fails. RAID creates **redundancy** by duplicating or distributing data across multiple disks, sacrificing some storage capacity to provide **fault tolerance**. To the operating system, the RAID array appears as a single storage unit that can be partitioned and formatted like any other drive. RAID can be implemented as **software RAID**, using the operating system, or as **hardware RAID**, which uses a dedicated RAID controller card or integrated motherboard features. Hardware RAID offers advanced features like **hot swapping**, allowing failed disks to be replaced without shutting down the system. Different **RAID levels**, such as RAID 0, RAID 1, RAID 5, and RAID 10, provide varying balances of performance and data protection.

When implementing RAID, it is very important to select the appropriate RAID level. This decision will be affected by the required level of fault tolerance, read/write performance characteristics, required capacity and cost.
When setting up the RAID array, it is best to use disks that are of **same size and type** for optimal performance. If you include disks of different sizes in the array, the system will only use the storage capacity equal to the **smallest disk** across all the disks. For example, if you have a **1TB** disk and a **500GB** disk in a RAID array, only **500GB** from each disk will be used, leaving the extra space on the larger disk unused. This ensures consistency but also means you waste the extra capacity on larger disks.

RAID 0 (Striping without Parity):

Disk Striping means dividing the data into smaller blocks and spreading them across multiple disks in the array. RAID 0 also divides the data into smaller blocks and spreads them across multiple disks that are available in the array. This improves performance because multiple disks can handle data requests at the same time. **RAID 0** needs at least two disks, and the total storage size is determined by the smallest disk in the array. However, **RAID 0 has no redundancy**, meaning if even one disk fails, all data in the array is lost. This makes it unsuitable for critical data storage and is typically used for non-essential tasks, like temporary file storage or caching, where speed is more important than data safety. We call RAID 0 as **Striping Without Parity** because unlike other RAID levels, RAID 0 doesnot include any parity information. Parity is extra data that helps rebuild lost information if a disk fails. Since RAID 0 skips this redundancy, it cannot recover data if any disk in the array fails.

RAID 1 (Mirroring):

RAID 1, also known as **mirroring**, uses two disks to store the same data. Whenever data is written, it is **duplicated on both disks simultaneously**, ensuring there's always an exact copy available. This setup provides excellent protection against disk failure because if one disk fails, the other can continue working without losing any data.
Key Points:

- **Fault Tolerance**: If one disk fails, the other takes over immediately, keeping the system running without noticeable downtime.
- **Performance**:
  - **Writes**: A small performance slowdown occurs because data is written to both disks.
  - **Reads**: Can be slightly faster since either disk can be used to retrieve data.
- **Rebuilding**: When a failed disk is replaced, the system copies data from the healthy disk to the new one. This process is faster than parity-based RAID systems.

- **Cost**: RAID 1 is more expensive because it uses **two disks for the same amount of data**, meaning only **50% of total disk space** is usable.

RAID 1 is ideal for situations where **data protection** is critical, such as storing important documents or running an operating system that requires high availability.

RAID 5 (Striping with Distributed Parity):

RAID 5 combines **striping** (spreading data across multiple disks) and **parity** (error correction information) to provide both performance and fault tolerance. Here's how it works:

1. **How It Works**:
    - Data and parity information are distributed across all disks in the array.
    - Parity ensures that if one disk fails, the missing data can be reconstructed using the remaining disks.
2. **Performance**:
    - **Reads**: RAID 5 offers fast read performance because data is striped across multiple disks.
    - **Writes**: Writing data is slower because the system needs to calculate and write parity information.
3. **Fault Tolerance**:
    - If **one disk fails**, the array can continue working because the parity information allows the missing data to be rebuilt.
    - If **more than one disk fails**, all data is lost.
4. **Disk Requirements**:
    - Requires a minimum of **three disks**.
    - As more disks are added, a smaller percentage of space is reserved for parity, increasing usable storage.
5. **Storage Example**:
    - In a 3-disk RAID 5 setup, one disk storage capacity is used for parity. So, with three 80GB disks, the total usable space is **160GB** (240GB total capacity minus 80GB for parity).
6. **Advantages**:
    - Good balance of performance, fault tolerance, and usable storage.
    - More efficient use of storage compared to RAID 1.
7. **Disadvantages**:
    - Slower write performance due to parity calculations.
    - Vulnerable if more than one disk fails at the same time.

RAID 5 is commonly used in servers and systems where both speed and data protection are important, such as in business applications or file servers.

RAID 10(Stripe of Mirrors):

RAID 10, also called **RAID 1+0**, is a **nested RAID configuration** that combines the benefits of **RAID 0** (striping) and **RAID 1** (mirroring). Here's how it works:

1. **How It Works**:
    - RAID 10 uses **striping** to split data across multiple disks for performance (RAID 0).
    - It also mirrors each striped set (RAID 1), creating a backup of each disk.
2. **Fault Tolerance**:
    - At least **one disk in each mirrored pair** can fail without losing data.
    - This ensures high availability and excellent fault tolerance.
3. **Disk Requirements**:
    - Requires a **minimum of four disks** and must use an **even number of disks**.
    - Half of the total storage capacity is used for mirroring, meaning **50% of disk space is reserved for redundancy**.

4. **Performance**:
    - Combines the speed of RAID 0 with the data protection of RAID 1.
    - Read and write performance is excellent.
5. **Key Advantages**:
    - High fault tolerance: Multiple disk failures are tolerated as long as no mirrored pair fails completely.
    - Excellent performance for both read and write operations.
6. **Key Disadvantage**:
    - Expensive: Half of the total disk capacity is used for mirroring, making it less storage-efficient.

RAID 10 is ideal for critical applications like databases and business servers where both speed and data protection are crucial.

Removable Storage Devices:

Those devices that we can carry from one place to another. Or those devices that can be moved from one computer to another computer without needing to open the case.

Optical Drives:

Optical drives are devices used to read and write data on **Compact Discs (CDs)**, **Digital Versatile Discs (DVDs)**, and **Blu-ray Discs (BDs)**. These formats are commonly used for storing music, videos, and PC data.

Storage Capacity and Speed:

1. **CD (Compact Disc)**:
    - Capacity: **700 MB**.
    - Transfer Speed: **150 KBps** (base speed).
    - Formats: **CD-R (recordable)**, **CD-RW (rewritable)**.
2. **DVD (Digital Versatile Disc)**:
    - Capacity:
        - **4.7 GB** (single-layer, single-sided).
        - Up to **17 GB** (dual-layer, double-sided).
    - Transfer Speed: **1.32 MBps** (9x CD speed).
    - Formats: **DVD+R/RW**, **DVD-R/RW** (most drives support both).
3. **Blu-ray (BD)**:
    - Capacity: **25 GB per layer**.
    - Transfer Speed: **4.5 MBps** (base), up to **72 MBps** (16x speed).

How Optical Drives Work:

- Use a **laser** to read and write data from the disc surface.
- Scratches can make the disc unreadable, despite being marketed as durable.

Installation and Connection:

1. **Internal Drives**:
   - Installed in a **5.25-inch drive bay**.
   - Connects via **SATA data and power cables**.
2. **External Drives**:
   - Connect via **USB**, **eSATA**, or **Thunderbolt**.
   - Require an external power supply (AC adapter)

Some Questions and Answers:

True or False: A solid-state drive (SSD) attached to an M.2 port must be using the non-volatile memory host controller interface specification (NVMHCI) or NVM Express (NVMe).

- **False**: An M.2 SSD can use either NVMe or SATA protocols, depending on the drive and the M.2 slot's capabilities.

What basic factor might you look at in selecting a high-performance hard disk drive?

- **Answer**: The **RPM (Revolutions Per Minute)** is a key factor, as higher RPM drives (e.g., 10,000 or 15,000 RPM) offer better performance.

If you have a computer with three hard disks, what type of RAID fault-tolerant configuration will make the best use of them?

- **Answer**: **RAID 5** is the best configuration for three disks, as it provides both fault tolerance and efficient use of storage with parity distributed across the disks.

You are configuring four 120 GB drives in a RAID 5 array. How much space will be available?

- **Answer**: In RAID 5, the equivalent of one disk is used for parity.
  Total capacity = 4 x 120 GB = 480 GB
  Usable space = 480 GB - 120 GB (parity) = **360 GB**

What is the minimum number of disks required to implement RAID 10, and how much of the disks' total capacity will be available for the volume?

- **Answer**: RAID 10 requires a **minimum of 4 disks**, and only **50% of the total capacity** will be available for use, as the other half is used for mirroring.

True or False: A memory card reader is needed to attach a thumb drive to a PC.

- **False**: A thumb drive connects directly to a PC via a **USB port** and does not require a memory card reader.