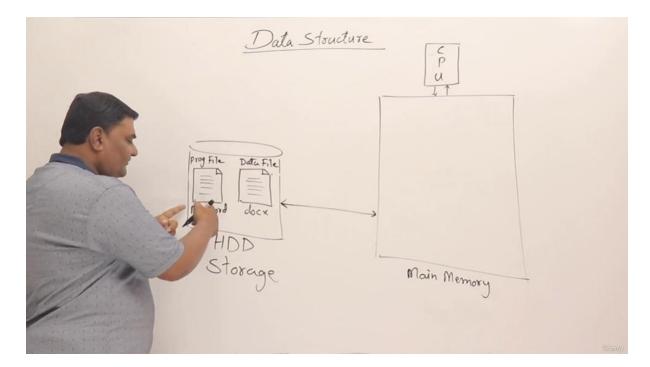🧠 **Introduction to Data Structures – Complete Notes**

1. What is Data?

- Data is the **core part** of any application or program.

- A **program** = set of instructions that operate on data to produce results.

- Without data, instructions are useless.

- Data appears in different contexts:

    o **Data Structures** (in-memory organization)

    o **Databases** (on-disk organization)

    o **Data Warehouses** (historical data storage)

    o **Big Data** (massive data on the internet)

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2. Definition of Data Structure

Data Structure = Arrangement of collection of data items so that they can be utilized and operated efficiently.

- Focuses on:

    o **Arrangement** of data

- o **Efficient operations** on data
- Exists **inside main memory (RAM)** during program execution.
- Every application uses data structures — there's no application without them.

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3. Where Does Data Structure Exist?

- During program execution, both **program instructions** and **data** must be in the **main memory (RAM)**.
- The CPU executes the program and performs operations on that data in memory.

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4. Example: MS Word

Components:

- **Program File (MS Word)** – installed on storage (hard disk).
- **Data File (Document)** – stored on disk as .docx.

When you open MS Word:

1. The **MS Word program file** is loaded from **storage → main memory**.
2. The **CPU** starts executing instructions.
3. When you open a document, the **data file** (the .docx) is also brought into **main memory**.
4. The program's instructions operate on that data in memory.

Hence:

- Program and data both reside temporarily in **RAM** during execution.
- The **way data is organized in memory** for efficient access → that's the **data structure**.

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5. Why Data Structures Matter

- Every application uses data:
  - o MS Word → document data
  - o Notepad → text file
  - o Chrome → web page data
- All this data must exist **in main memory** while being processed.
- Efficient organization of this in-memory data = faster performance.
- Therefore, **Data Structures** are used by every application to:
  - o Store data temporarily in RAM

o   Access and modify it efficiently

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6. Where Exactly Are Data Structures Formed?

- Formed **inside main memory** (RAM) when the program runs.

- Exist **only during execution time**.

- Disappear when the program terminates.

So,

Data Structure = runtime arrangement of data inside main memory for efficient processing.

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7. Examples of Data Structures

- Arrays

- Linked Lists

- Trees

- Hash Tables

- Queues, Stacks, Graphs, etc.

Applications use whichever data structure suits their operations best.

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8. Types of Data Stored

- **Text Data:** e.g. characters, strings

- **Multimedia Data:** images, audio, video

- **Numerical / Structured Data:** tables, matrices
  Data structures help organize all these efficiently for quick operations.

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9. Summary of Where Data Lives

Component	Location	Description
Program	RAM (during execution)	Instructions being executed
Data	RAM (during execution)	Data currently being used
Storage / Disk	Hard Disk	Permanent data & program files
Data Structure	Main Memory	Arrangement of data during runtime

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🎯 Database Overview

1. What is a Database?

A **Database** is an organized collection of data, typically arranged in **tables** and stored permanently on disk.

- Designed for **large commercial data** (like banking, retail, manufacturing).

- Stores data in **tables** (rows and columns).

- Multiple tables can have **relationships**.

- Stored on **hard disk** (permanent memory).

2. How Applications Use Databases

- When a program needs data from a database:

    o Data is **fetched from disk → into main memory**.

    o Once in memory, the program uses **data structures** to manipulate it.

So:

Database = organized data on disk
Data Structure = in-memory arrangement of that fetched data

📇 Data Warehouse
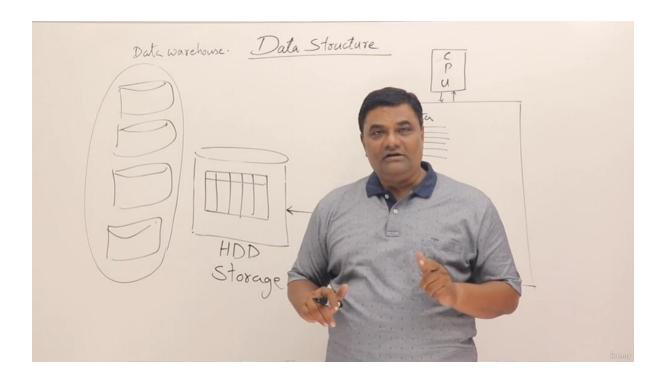
1. Why Data Warehouses Exist

- Large organizations generate **massive amounts of data daily**.

- Old data isn't used for daily operations but is valuable for analysis.

- So data is categorized as:

    o **Operational Data:** frequently used, current data

    o **Historical / Legacy Data:** old data, rarely accessed but useful for analysis

2. Definition

Data Warehouse = storage of large, historical data (not used daily) across multiple disks, used mainly for analysis and decision-making.

3. Purpose

- Helps analyze trends, performance, and customer behavior.

- Supports decision-making and business intelligence.

- Analysis done using **Data Mining Algorithms**.

🌐 **Big Data**

1. Definition

Big Data = extremely large volumes of data generated on the Internet every day about people, places, activities, etc.

- Emerged with the growth of the Internet.

- Data comes from social media, transactions, sensors, IoT devices, etc.

- Used for analytics, governance, business insights.

2. Focus

- Storing, processing, and analyzing **massive** data sets efficiently.

- Enables better **decision-making**, policy creation, and management.

✖ Comparison Summary

Term	Storage Location	Usage	Example
Data Structure	Main Memory (RAM)	During program execution	Array, Linked List
Database	Disk (Permanent)	Daily operational data	Banking records, transactions
Data Warehouse	Array of Disks	Historical, analytical data	10-year sales data
Big Data	Internet scale (Distributed Storage)	Global data analysis	Social media analytics