INFORMATION AND COMMUNICATION TECHNOLOGY

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1. Basics of Computers and Information Technology

Artificial Intelligence (AI) and Machine Learning (ML) Basics: Core Concepts and Applications

- **C-DAC (Centre for Development of Advanced Computing)**
  - Established in 1987 with the primary objective to build Supercomputers, addressing technology denial by countries like the USA.
  - Pioneered Indian Language Computing Solutions through its GIST (Graphics and Intelligence based Script Technology) group.
- **Turing Machine**
  - A theoretical computing machine, conceptualized by Alan Turing.
  - Serves as an ideal model for mathematical computation and forms the basis of computability theory.

- **Turing Test / Imitation Game**
  - Originally known as the 'Imitation Game', proposed by Alan Turing.
  - A test of a machine's ability to exhibit intelligent behavior equivalent to, or indistinguishable from, that of a human.
  - A foundational concept in Artificial Intelligence for evaluating machine intelligence.

Computer Hardware: Components (CPU, Memory, Input/Output Devices, Storage)

- **PARAM 8000** was India's first supercomputer (1991).
- **PARAM** series are examples of **Supercomputers**.
- **Param-Ishan** is a **Supercomputer**.
- India's first computer was installed at the **Indian Statistical Institute, Calcutta** (HEC-2M, 1956).
- **Charles Babbage** is known as the "Father of the Computer".
- The **first electronic digital computer (ENIAC)** was developed in **1946**.
- **UNIVAC (Universal Automatic Computer)** was the first general-purpose electronic digital computer designed for commercial use.
- **General-purpose computers** exist in a wide range of sizes and power.
- **Hybrid computers** combine features of both analog and digital computers.
- **Silicon Valley, USA**, is famous for **electronics** (semiconductor industry).
- **MOEMS** stands for **Micro-Opto-Electro-Mechanical-Systems**.
- **LED** stands for **Light Emitting Diode**.
- **Liquid crystals** are most importantly applied in **digital displays (LCDs)**.
- A **modem** is a device that connects a computer to a phone line (or other network) for data transmission.
- **Magnetic Resonance Imaging (MRI)** generates thin section images of human body parts.
- **QWERTY** keyboard layout: letters start with Q, W, E, R, T.
- **Dvorak** keyboard layout: ergonomic, places common keys (e.g., vowels on left, common consonants on right) for ease of typing.
- **Dextr** keyboard layout: keys in alphabetical order.
- **KALQ** keyboard layout: optimized for thumb typing.
- A **badge reader** is a device designed to read information encoded into small plastic cards.
- **OMR (Optical Mark Recognition)** is an optical input device that interprets pencil/pen marks on paper.

Computer Networks: Types (LAN, WAN, MAN), Network Topologies, Internet Fundamentals (WWW, Email, Protocols)

- **Information Technology (IT)**

  Defined as Computers + Connectivity.

- **NASSCOM**

  National Association of Software and Service Companies.

- **Computer Network Types**
  - **LAN (Local Area Network)**

    Covers a small geographical area (e.g., home, office). High data transfer rates.
  - **MAN (Metropolitan Area Network)**

    Spans a city or large campus. Connects multiple LANs.
  - **WAN (Wide Area Network)**

    Covers a large geographical area (e.g., countries, continents). Connects multiple LANs/MANs; the Internet is the largest WAN.
- **Network Topologies**

  (Physical or logical arrangement of network devices)
  - **Bus**

    All devices share a single communication line (backbone). Simple but single point of failure.
  - **Star**

    All devices connect to a central hub/switch. Easy management; central device failure affects all.

- **Ring**

  Devices connect in a circular fashion; data flows in one direction. Break in ring disrupts entire network.

- **Mesh**

  Every device is connected to every other device. High fault tolerance and redundancy, but complex and costly.

- **Tree**

  A hierarchy of star networks. Scalable.

- **Internet Fundamentals**
  - **WWW (World Wide Web)**

    A global system of interconnected hypertext documents accessed via the Internet.

    - **Favicon**

      A small icon associated with a particular website.

    - **Downloading**

      Transferring a file from a server to a client computer.

  - **Email (Electronic Mail)**

    Method of exchanging digital messages.

    - **Protocols**

      SMTP (Simple Mail Transfer Protocol) for sending; POP3 (Post Office Protocol version 3) and IMAP (Internet Message Access Protocol) for receiving.

  - **Key Internet Protocols**

    - **TCP/IP (Transmission Control Protocol/Internet Protocol)**

      Fundamental suite for Internet communication.

    - **HTTP (Hypertext Transfer Protocol)**

      Basis for data communication on the WWW.

    - **HTTPS (HTTP Secure)**

      Encrypted version of HTTP using SSL/TLS.

    - **FTP (File Transfer Protocol)**

      For transferring files between computers. Originally designed by Abhay Bhushan.

    - **DNS (Domain Name System)**

      Translates human-readable domain names (e.g., google.com) into numerical IP addresses.

      - **Reverse Lookup**

        Maps an IP address back to its corresponding domain name using PTR (Pointer) records.

    - **DHCP (Dynamic Host Configuration Protocol)**

      Assigns IP addresses and other network configuration parameters to devices. Supports zero-conf and plug-and-play.

    - **Gnutella**

      A peer-to-peer (P2P) network protocol primarily used for file sharing.

Computer Software: Types (System, Application), Programming Languages (Basic Concepts)

- Computer Software: Set of instructions, data, or programs used to operate computers and execute specific tasks.
- Software is broadly categorized into System Software and Application Software.
- System Software: Manages and controls computer hardware and software resources; e.g., Operating Systems (Windows, Linux), Device Drivers.
- Application Software: Designed to perform specific tasks for the end-user; e.g., Word Processors, Spreadsheet programs.
- MS Excel: A prominent example of application software, known as a spreadsheet program within the Microsoft Office suite.
- Programming Languages: Formal languages consisting of a set of instructions used to create computer programs.

- LOGO: A programming language devised by D.G. Bobrow, W. Feurzeig, Seymour Papert, and C. Solomon.
- Multimedia: Can contain various data types including graphics, animation, video, music, and voice, processed by specific application software.
- File Formats: `.MP3` is an audio file format; `.MP4`, `.MOV`, `.AVI` are common video file formats.
- Bangalore: Widely recognized as the "Software Capital of India".
- India's IT Industry: Characterized by strong software development and exports, but a comparatively weaker hardware manufacturing base.

Cybersecurity Basics: Common Threats (Malware, Phishing), Basic Protective Measures (Antivirus, Firewall)

- **Cybersecurity:** Protection of internet-connected systems (hardware, software, data) from cyber threats.
- **Common Threats:**
  - **Malware (Malicious Software):** Programs designed to gain unauthorized access, disrupt operations, or cause damage to computer systems.
    - **Virus:** Attaches to legitimate programs; self-replicates; requires user interaction (e.g., opening infected file) to spread.
    - **Worm:** Self-replicating; standalone malware; spreads autonomously across networks without user interaction.
    - **Trojan Horse:** Disguises as legitimate software; performs malicious actions (e.g., creating backdoors) once executed; does not self-replicate.
    - **Ransomware:** Encrypts user data and demands a ransom payment (often cryptocurrency) for its decryption key.
    - **Spyware:** Secretly monitors and collects information about a user's activities (e.g., browsing history, keystrokes).
    - **Adware:** Displays unwanted or intrusive advertisements, often bundled with free software.
    - **Rootkit:** A set of software tools designed to hide its presence and allow continued privileged access to a computer system.
  - **Phishing:** Fraudulent attempt to obtain sensitive information (e.g., usernames, passwords, credit card details) by disguising as a trustworthy entity in electronic communication.
    - **Spear Phishing:** Highly targeted phishing attack against specific individuals or organizations.
    - **Whaling:** Phishing attack specifically aimed at high-profile targets like senior executives.
    - **Smishing:** Phishing conducted via SMS (text messages).
    - **Vishing:** Phishing conducted via voice calls.
    - **Pharming:** Redirects users to fake websites, even if the correct URL is typed, by corrupting DNS records or host files.
- **Basic Protective Measures:**
  - **Antivirus Software:** Detects, prevents, and removes malicious software (viruses, worms, Trojans, ransomware, etc.) from a computer system by scanning files, emails, and web activity.
  - **Firewall:** A network security system that monitors and controls incoming and outgoing network traffic based on predetermined security rules; acts as a barrier between a trusted internal network and untrusted external networks (e.g., the internet).

Data Representation and Units of Measurement (Bits, Bytes, KiloBytes, etc.)

- **Fundamental Units**
  - **Bit (Binary Digit)**

    Smallest unit of data, representing a 0 or 1.

- **Nibble**

  Group of 4 bits.

- **Byte**

  Group of 8 bits. It is the smallest addressable unit of memory.

- **Data Storage Hierarchy (Binary Prefixes, Base 2)**
  - 1 Kilobyte (KB) = 1024 Bytes = 2^{10} Bytes.
  - 1 Megabyte (MB) = 1024 KB = 2^{20} Bytes.
  - 1 Gigabyte (GB) = 1024 MB = 2^{30} Bytes.
  - 1 Terabyte (TB) = 1024 GB = 2^{40} Bytes.
  - 1 Petabyte (PB) = 1024 TB = 2^{50} Bytes.
  - 1 Exabyte (EB) = 1024 PB = 2^{60} Bytes.
  - 1 Zettabyte (ZB) = 1024 EB = 2^{70} Bytes.
  - 1 Yottabyte (YB) = 1024 ZB = 2^{80} Bytes.
- **Number Systems & Conversions**
  - **Binary System**

    Base-2, uses digits 0 and 1. Requires more places to represent a number than decimal due to its smaller base.

  - **Decimal System**

    Base-10.

  - **Hexadecimal System**

    Base-16, uses digits 0-9 and letters A-F.

  - **Binary Conversions**
    - $(111)_2 = 7_{10}$.
    - $(12)_{10} = 1100_2$.
    - $(53)_{10}$ requires 6 bits for representation (e.g., 110101_2).
    - $(187)_{10} = 10111011_2$ (in 8-bit binary).
    - $(010111100)_2 = 274_8$ (grouping 3 bits: 010 | 111 | 100).
  - **Hexadecimal to Decimal**

    $(4A9.2)_{16} = 1193.125_{10}$ ($4*16^2 + 10*16^1 + 9*16^0 + 2*16^{-1}$).
- **Data Representation in Computers**
  - Computers internally represent data using the

    Binary system.
  - BCD (Binary Coded Decimal) Each decimal digit is represented by its 4-bit binary equivalent.
    - Example: 87.34_{10} = 1000 0111 . 0011 0100 (BCD).
  - **Signed-Magnitude Representation**

    The Most Significant Bit (MSB) is reserved for the sign bit (0 for positive, 1 for negative).

  - **Two's Complement**

    Used for representing signed numbers and performing arithmetic operations.
    - Binary subtraction of $(100)_2 - (011)_2 = (001)_2$.
    - Binary addition of -8 and -2 in two's complement (e.g., 5-bit representation): -8 = 11000, -2 = 11110, result -10 = 10110.
- **Character Encoding Standards**
  - **ASCII**
    - Full Form:

      American Standard Code for Information Interchange.
    - **Originally a 7-bit code, representing 128 characters.**
    - **Contains 94 standard printing characters.**
  - Unicode A universal character encoding standard.
    - **UTF (Unicode Transformation Format)**

      Stands for Unicode Transformation Format.
    - Unicode encoding schemes (like UTF-16) often represent a character as a group of 16 bits.

- **Computer Performance & Display**
  - **Processing Speed Units**

    MHz (MegaHertz), MIPS (Millions of Instructions Per Second), MFLOPS (Millions of Floating-point Operations Per Second). MOFS is not a standard unit.
  - **Resolution**

    Refers to the sharpness of a television image or display, measured in pixels.
    - 1080p with a 16:9 picture aspect ratio typically means a display resolution of 1920 x 1080 pixels.
  - Historically, in December 1996, the world's fastest computer performed approximately 10^{12} operations per second (TFLOPS range).
- **Data, Information, Knowledge Flow**
  - The correct sequence is: Data → Information → Knowledge.
  - **Data**

    Raw facts.
  - **Information**

    Processed Data.

Data Storage and Management: Types of Storage, Data Backup and Recovery

- FAT stands for File Allocation Table.
- Proper preservation of records includes maintaining ambient humidity/temperature and keeping the storage area free of dust. Usage of signages is not directly related to physical preservation.
- Michael Cook authored "The Management of Information from Archives."
- ISO 15489 is the International Organization for Standardization's record management standard.
- During Thymol fumigation, Thymol is placed at the bottom shelf of the fumigation almirah (chamber) for heating.
- ERM stands for Electronic Record Management.
- The standard GSM (Grams per Square Meter) for tissue paper is typically 9-11 GSM.
- Microfilming is related to Microfiche, Aperture Cards, and Microstrip. An Index Card is not directly a microfilming format or process component.
- Dichloroethylene is used to remove pressure-sensitive tape (Cello tape) from documents.
- Chiffon is also known as Silk gauze.
- Methoxy Magnesium Methyl Carbonate (MMMC) is used for Mass Deacidification in the conservation of documents.

Database Management Systems (DBMS) Basics: Concepts, Types of Databases

- ACID properties in DBMS transaction management stand for Atomicity, Consistency, Isolation, Durability.
- In a B+ tree index, leaf nodes store pointers to actual file records (or block addresses) and are linked sequentially. Non-leaf nodes store key values and pointers to child nodes.
- Relational algebra operations Union ($\cup$) and Intersection ($\cap$) are associative, e.g., $R \cup (S \cup T) = (R \cup S) \cup T$.
- When a foreign key attribute is updated, the DBMS must ensure the new value is either NULL or refers to an existing primary key in the referenced relation (referential integrity).
- The recovery manager in DBMS transaction processing ensures the atomicity and durability properties of transactions, especially after system failures.
- The SQL `UNION` operator combines the result sets of two or more `SELECT` statements, returning only distinct rows (removing duplicates automatically). The selected columns must have compatible data types.
- In object-oriented databases, persistent objects survive program termination and are stored in non-volatile memory for retrieval in future sessions.
- Atomicity (part of ACID properties) ensures that a transaction is an indivisible unit of work; it is either fully executed or not performed at all.
- In ER diagrams, a 'weak entity' depends on an 'owner' (identifying) entity for its existence and identification and does not have a primary key of its own, but a partial key.

- The primary goal of Boyce-Codd Normal Form (BCNF) in database normalization is to eliminate redundancy caused by functional dependencies, ensuring all determinants are super keys.
- The SQL `LIKE` operator with the wildcard `%` is used to search for a specified pattern in a column (e.g., `WHERE Address LIKE '%AJMER%'` finds 'AJMER' anywhere).
- Natural join (⋈) combines tuples from two relations based on equality of their common attributes. The result schema includes all attributes from both relations, with common attributes appearing only once. For R(A, B, C) and S(B, C, D), the resulting schema is (A, B, C, D).
- In relational algebra, the selection operation (σ) filters tuples (rows) based on a predicate, while projection (π) selects attributes (columns).
- Embedded SQL allows SQL commands to be integrated and called from a host programming language.
- Data abstraction in a DBMS aims to hide the physical implementation details of data storage from users.
- For N transactions, the number of possible serial schedules is N! (N factorial). For 5 transactions, 5! = 120.
- The SQL `GROUP BY` clause groups rows with the same values, and the `HAVING` clause filters these groups based on a specified condition, often using aggregate functions.
- Chaining (Open Hashing) is a collision resolution technique where all keys that hash to the same index are stored in a linked list.
- In query optimization, join order is important because it significantly affects the size of intermediate results and thus the query execution cost.
- **Database Constructs Definitions**
  - **Trigger**

    Automatically executes active rules on occurrence of events (e.g., INSERT, UPDATE, DELETE).
  - **Cursor**

    Enables processing of a query result set row by row.
  - **Stored Procedure**

    Precompiled SQL statements stored at the database server for repeated execution.
  - **View**

    A virtual table derived from one or more base tables, defined by a query.
- Two-Phase Locking (2PL) is a common concurrency control protocol that ensures serializability.
- For set operations (`UNION`, `INTERSECT`, `MINUS`/`EXCEPT`), relations must be union-compatible (same number and compatible data types of columns).
- In embedded SQL, a colon (`:`) prefix refers to host variables within SQL statements.
- A super key is any set of attributes that uniquely identifies a tuple. A candidate key is a minimal super key (no redundant attributes), and every candidate key is a super key.
- An SQL view is generally updatable if it is based on a single base table, its `SELECT` clause contains only attribute names (no expressions, aggregates, `DISTINCT`), attributes not selected can be `NULL` (or have defaults) and are not part of the primary key, and it does not use `GROUP BY`, `HAVING`, `UNION`, etc.
- An insertion anomaly occurs when data about one entity cannot be inserted without existing data about another, or when inserting new data creates redundancy.
- The primary goal of query optimization in a DBMS is to find the most efficient and cost-effective execution plan for a query.
- In a relational database context, a column in a table is an Attribute; a row is a Tuple (or record).
- **Library Science Concepts (as per MCQs)**
  - In MARC-21, tag 260 indicates Publication Information.
  - The Main Entry provides the most complete bibliographic information about a book.

- In SEARS List of Subject Headings, "BT" denotes "Broader Term."
- The standard size of a catalogue card is 12.5 cm x 7.5 cm.
- In Colon Classification, a time period like 1987 to 2019 is represented as N87 → P19.
- Colon Classification uses Mixed Notation (combining various symbols).
- In the facet formula for "O Literature" (O[P],[P2],[P3],[P4]), [P] (Personality) denotes the Language.
- In Colon Classification, 'w' is used as the common isolate for biography.
- In chain procedure, subject headings are derived from the Class Number of the document.
- WINISIS is the Windows version of UNESCO's CDS/ISIS software.
- Fostering reading habits and self-education are objectives of School and Public Libraries.
- College Libraries fall under Academic Libraries.
- The Delhi Public Library (DPL) was established with assistance from UNESCO.
- The University of Delhi started the first post-graduate course in Library Science in India.
- The Raja Rammohan Roy Library Foundation (RRRLF) was established in 1972.
- Dr. S.R. Ranganathan's Fourth Law of Library Science is "Save the time of the Reader."

- In an ER Model, multiple skills of an employee are best represented by a Multivalued Attribute.
- In the Relational Model, Domain Constraints (or 1NF) do not allow composite and multivalued attributes; each attribute must hold only atomic, single values.
- The Cartesian product (X × Y) of two relations results in (number of tuples in X) * (number of tuples in Y) tuples. For X(4 tuples) and Y(3 tuples), X × Y = 12 tuples.
- Relational Algebra Set operations: Selection (σ) filters rows, Projection (π) selects columns, Set Difference (-) returns tuples in the first relation but not the second, Intersection ($\cap$) returns common tuples.
- A decomposition of relation R(A,B,C,D) into R1(AB) and R2(CD) with FDs A→B, C→D is dependency preserving but not lossless join (because R1 $\cap$ R2 = $\emptyset$, which does not determine R1 or R2).
- The expression `(A $\cap$ B) $\cup$ (B $\cap$ A)` simplifies to `A $\cap$ B`. The expression `(A $\cup$ B) - (A $\cap$ B)` represents the symmetric difference.
- A `View` in a database is a virtual table created by querying one or more tables.
- Natural Join (R1 ⋈ R2) combines tuples based on common attributes. To calculate the number of tuples, count how many times common attribute values match across both relations.

- **B+ Tree and Indexing**
  - In a B+ tree, each non-leaf node has between $\lceil n/2 \rceil$ and n children (where n is the order/fixed maximum children).
  - The search key of a clustering index can be any attribute(s) for which records are physically ordered.
  - Secondary indices must be dense (an index entry for every search-key value).
  - In a dense index, an index entry appears for every search-key value.
- Any relation not physically stored but made visible to a user as a virtual relation is called a View.
- Two-Phase Locking (2PL) protocol is prone to deadlocks and can lead to cascading rollbacks.
- A relation R(A, B, C, D) with primary key A and FDs A → B, B → C, C → D is not in BCNF (nor 3NF) because B → C and C → D have determinants (B and C) that are not super keys, and dependents (C and D) that are non-prime attributes.
- The relationship "a person has an Aadhaar Card" is a One-to-One relationship.
- An organized collection of logically related data is called a Database.

- Indices whose search key specifies an order different from the sequential order of the file are called Secondary Indices.
- Timestamp Ordering concurrency control ensures conflict serializability and is deadlock-free. 2PL and Multiple Granularity Protocol are prone to deadlocks.
- In embedded SQL, the `SELECT INTO` statement is used to fetch data into host variables.
- For a relation R(A, B, C) with {B} as the only candidate key, the super keys are {B}, {B, A}, {B, C}, {B, A, C}.
- The cardinality of a relational table is the number of tuples (rows). The degree is the number of attributes (columns).
- The Set-Difference operation allows finding tuples that are in one relation but not in another.
- Data Manipulation Language (DML) commands (`SELECT`, `INSERT`, `UPDATE`, `DELETE`) are used to query and update a database.
- An Entity-Relationship (ER) Model describes the Conceptual Schema of a database.
- The number of attributes in a relation is known as the Degree of the relation.
- The Natural Join operation requires two relations as input, and these relations must have common attributes.
- The complete description or structure of data stored in a database is known as the Schema.

Emerging Technologies Overview: Big Data, Blockchain (Conceptual Understanding)

- Jeff Bezos: Amazon.
- Elon Musk: Tesla, SpaceX, Neuralink, X.
- Tim Cook: Apple.
- India's supercomputer program: Started late 1980s.
- PARAM 8000: India's first supercomputer (developed by C-DAC, 1991).
- PARAM 10.000: Supercomputer.
- Aaditya supercomputer: Located at Indian Institute of Tropical Meteorology (IITM), Pune.
- Y2K: Computer bug.
- Noise pollution: Measured in Decibel (dB).

Mobile Computing: Devices, Operating Systems, Applications

- SIM: Subscriber's Identity Module.
- Mobile Phone Inventor: Martin Cooper.

Web Technologies: HTML, Browsers, Search Engines, World Wide Web

- World Wide Web (WWW) was introduced by Tim Berners-Lee in **1989**.
- Launch of the first communications satellite: **1962**.
- Completion of a continuous around-the-world fibre-optic cable link: **1997**.
- Creation of the SWIFT system for worldwide electronic interbank fund transfer: **1977**.
- **Google** launched the Indian Language Internet Alliance (ILIA).
- **C2B (Consumer-to-Business)** is an e-commerce model where consumers fix prices and businesses accept or decline.
- Wikipedia was founded in **2001**.
- Google's Alphabet website is **abc.xyz**.
- **GIS** stands for Geographic Information System.
- **Global reach** is the e-commerce dimension enabling commerce beyond country boundaries.
- **URL** stands for Uniform Resource Locator.
- The first page of any website is called the **Home Page**.
- **Class Number** is a symbolic translation of the subject of a book.
- The **Public Library Association** is based in the United States.
- **H.P. Luhn** coined the term "KWIC" (Key Word In Context) in indexing.
- "**Indian Library Science Abstract**" is published by the Indian Association of Special Libraries and Information Centres (IASLIC).
- A **Patent** is an agreement between the inventor/producer and the Government for their invention/product.
- "**Referativny Zhurnal**" is an Abstracting periodical.
- **WINISIS** software was developed by UNESCO.
- **SOUL** stands for Software for University Libraries.

- The 'Universal Bibliographic Control' concept was coined by the **International Federation of Library Associations and Institutions (IFLA)**.

2. Components of a Computer System

Central Processing Unit (CPU): Architecture, ALU, Control Unit, Registers

- **Central Processing Unit (CPU) is the brain of the computer system, a processor device that performs calculations and makes decisions.**
- **CPU stands for** Central Processing Unit**.**
- **CPU speed is measured in** Hertz (Hz)**, typically** Gigahertz (GHz) **for modern processors.**
- **A** CPU cycle **is the time required for fetching and executing one simple machine instruction.**
- **The CPU chip is where the computer adds and compares data.**
- Components of CPU
  - **Arithmetic Logic Unit (ALU)**

    Performs arithmetic operations (e.g., addition, subtraction) and logical operations (e.g., comparisons, decisions).
  - **Control Unit (CU)**

    Interprets/decodes program instructions, initiates control operations, and manages/coordinates components of the computer system. It does not perform arithmetic/logic operations, store data in memory, or directly accept input data from the keyboard.
  - **Registers**

    Small, high-speed storage areas within the CPU used for temporary data storage during processing. Secondary memory is NOT a component of the CPU.
- **Registers**
  - Registers are basic components for storing data.
  - A **Flip-flop is a sequential electronic circuit used as the basic component for storing 1-bit information; D-type flip-flops are commonly used in registers.**
  - Accumulator (ACC) Stores the results produced by the Arithmetic Logic Unit (ALU).
  - **Program Counter (PC)**

    Stores the address of the next instruction to be executed by the computer.
  - **Memory Address Register (MAR)**

    Holds the address of the memory location that is to be accessed (read from or written to).
  - **Memory Data Register (MDR)**

    Holds the data that is being written to or read from the memory location specified by the MAR.
  - **Instruction Register (IR)**

    Holds the current instruction being executed.
  - A **Control Register is typically write-only.**
  - **Super Computers often have a** 64-bit **word length.**
- Address Bus A 32-bit address bus can address 2^{32} memory locations.
- **Data Bus**

  Carries data signals in bi-direction between components.
- Intel Core i9 is a type of **Processor.**
- Logic Gates
  - A **NOT gate** has 1 input line.
  - An **XNOR gate** produces a true (1) output when both input values are the same (0,0 or 1,1).