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SUPER IT

160++ QUESTION BOOK

A BOOK FOR CSE/IT BASED JOB

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Organized, Short and Effective

Written & Designed by



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MOFAZZAL HOSSAIN TITON

একমাত্র পরিবেশকঃ

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বইটি সম্পর্কে কিছু কথা

এই বইটি শুধু একটি প্রশ্নসংকলন নয়; বরং সিএসই/আইটি ভিত্তিক চাকরির পরীক্ষার জন্য গুরুত্বপূর্ণ টপিকগুলো নিয়ে সাজানো একটি পরিকল্পিত প্রস্তুতি গাইড।

আমার নিজের চাকরির পরীক্ষার অভিজ্ঞতা, প্রস্তুতির অভিজ্ঞতা এবং বিগত বিভিন্ন নিয়োগ পরীক্ষার প্রশ্ন বিশ্লেষণ করে সবচেয়ে গুরুত্বপূর্ণ ও বারবার আসা টপিকগুলো বাছাই করে বইটি সাজিয়েছি।

বইটি তৈরির সময় আমার মূল লক্ষ্য ছিল একটাই—**একজন পরীক্ষার্থী যেন অপ্রয়োজনীয় বিষয় পড়ে সময় নষ্ট না করে, স্বল্প সময়ে গুরুত্বপূর্ণ টপিকগুলো শেষ করে একটি ভালো প্রস্তুতি নিতে পারেন।**

এখানে প্রচলিত বইগুলোর মতো শুধু *'কাকে বলে', 'কত প্রকার', 'কী কী'*—এ ধরনের প্রাথমিক আলোচনা দিয়ে পৃষ্ঠা বাড়ানো হয়নি। বরং সরাসরি সেই প্রশ্ন ও টপিকগুলোকে গুরুত্ব দিয়েছি, যেগুলো একজন সিএসই/আইটি চাকরিপ্রার্থীর অবশ্যই জানা প্রয়োজন।

এই বইটি কীভাবে পড়বেন?

বইটি মূলত প্রশ্নভিত্তিক। এখানে কোনো একটি টপিক থেকে হয়তো একটি প্রশ্ন দেওয়া হয়েছে। কিন্তু আপনার কাজ শুধু সেই প্রশ্নের উত্তর মুখস্থ করা নয়; বরং প্রশ্নটির মাধ্যমে টপিকটি চিহ্নিত করে এর সঙ্গে সম্পর্কিত অন্যান্য গুরুত্বপূর্ণ বিষয়ও ভালোভাবে বুঝে পড়া।

মনে রাখবেন, **প্রশ্ন মুখস্থ করার চেয়ে পরীক্ষায় কোন টপিক থেকে, কী ধরনের প্রশ্ন আসে এবং কেন আসে—সেটি বুঝতে পারা অনেক বেশি গুরুত্বপূর্ণ।**

আপনি যত দ্রুত পরীক্ষার প্রশ্নের ধরন ও গুরুত্বপূর্ণ টপিকগুলো বুঝতে পারবেন, আপনার প্রস্তুতি তত বেশি কার্যকর ও লক্ষ্যভিত্তিক হবে।

এই বই থেকে কতটুকু কমন পাবেন?

কোনো বই থেকেই পরীক্ষায় ১০০% প্রশ্ন কমন পাওয়ার নিশ্চয়তা নেই। আমিও এমন কোনো নিশ্চয়তা দিতে চাই না। তবে আমার বিশ্বাস, এই বই থেকে সরাসরি প্রশ্ন কমন না পড়লেও পরীক্ষার অধিকাংশ গুরুত্বপূর্ণ টপিকের সঙ্গে আপনার পরিচয় থাকবে, ইনশাআল্লাহ।

কারণ, বইটিতে সিএসই/আইটি চাকরির পরীক্ষার প্রচলিত সিলেবাসের গুরুত্বপূর্ণ বিষয়গুলোকে যতটা সম্ভব সংক্ষিপ্ত, গোছানো ও পরীক্ষাভিত্তিকভাবে উপস্থাপন করার চেষ্টা করেছি।

আমার পরামর্শ—আগে এই বইয়ের প্রশ্ন ও টপিকগুলো ভালোভাবে শেষ করুন। তারপর হাতে সময় থাকলে অন্যান্য বই বা উৎস থেকে বাড়তি বিষয় পড়ুন।

১ বছরের প্রস্তুতি ৩–৪ মাসে নেওয়ার লক্ষ্য

আমাদের অনেকেরই প্রস্তুতির জন্য পর্যাপ্ত সময় থাকে না। আবার কোন বিষয়টি পড়ব আর কোনটি বাদ দেব—এই সিদ্ধান্ত নিতেও অনেক মূল্যবান সময় নষ্ট হয়।

সেই সমস্যার কথা মাথায় রেখেই বইটি তৈরি করেছি, যাতে একজন পরীক্ষার্থী গুরুত্বপূর্ণ টপিকগুলো খুঁজে বের করার পেছনে সময় ব্যয় না করে সরাসরি পড়া শুরু করতে পারেন।

আমার লক্ষ্য হলো, সঠিক পরিকল্পনা ও নিয়মিত অধ্যয়নের মাধ্যমে একজন পরীক্ষার্থী যেন প্রচলিত দীর্ঘমেয়াদি প্রস্তুতির গুরুত্বপূর্ণ অংশগুলো ৩–৪ মাসের মধ্যেই শেষ করতে পারেন।

ব্যক্তিগতভাবে আমিও আমার প্রস্তুতির সময় মূলত এই টপিকগুলোর ওপরই গুরুত্ব দিয়েছি। সেই অভিজ্ঞতা থেকেই বলতে পারি, **এখানে দেওয়া প্রতিটি টপিক বুঝে শেষ করতে পারলে আপনার একটি শক্তিশালী ভিত্তি তৈরি হবে বলে আমি আশাবাদী।** তবে প্রস্তুতির মান নির্ভর করবে আপনার বোঝার ক্ষমতা, অনুশীলন, ধারাবাহিকতা এবং পরীক্ষায় তা প্রয়োগ করার দক্ষতার ওপর।

বইয়ের বাইরেও প্রস্তুতি চলবে

একটি নির্দিষ্ট বইয়ে সব সম্ভাব্য প্রশ্ন অন্তর্ভুক্ত করা সম্ভব নয়। তাই বইয়ের পাশাপাশি আপনাদের প্রস্তুতিকে আরও সহজ ও কার্যকর করতে আমাদের রয়েছে Bit to Exabyte ওয়েবসাইট।

বইয়ে নেই এমন কোনো প্রশ্ন বা টপিক নিয়ে সমস্যায় পড়লে আমাদের ওয়েবসাইটে প্রশ্ন করতে পারবেন। আমরা সেই প্রশ্নের উত্তর ও প্রয়োজনীয় ব্যাখ্যা সাজিয়ে PDF আকারে দেওয়ার ব্যবস্থা রেখেছি।

অর্থাৎ, বইয়ের শেষ পৃষ্ঠাতেই আপনার শেখা শেষ নয়; বরং প্রয়োজন অনুযায়ী নতুন প্রশ্নের উত্তর জানার সুযোগও থাকবে।

বইয়ের সঙ্গে প্রিমিয়াম মেম্বারশিপ

বইটি কিনলে আপনি আমাদের ওয়েবসাইটে **প্রিমিয়াম মেম্বারশিপ** পাওয়ার সুযোগ পাবেন। এর মাধ্যমে বইয়ের পাশাপাশি আমাদের অনলাইন প্রস্তুতি কার্যক্রম ও প্রিমিয়াম সুবিধাগুলোও ব্যবহার করতে পারবেন।

শেষ কথা

আমি এই বইটিকে সবকিছুর বিকল্প হিসেবে উপস্থাপন করতে চাই না। বরং এটি এমন একটি গাইড হিসেবে তৈরি করেছি, যা আপনাকে বুঝতে সাহায্য করবে—**কী পড়তে হবে, কেন পড়তে হবে এবং কোন বিষয়গুলো আগে শেষ করা জরুরি।**

আমার উদ্দেশ্য বইয়ের পৃষ্ঠা বাড়ানো নয়; আপনাদের প্রস্তুতির সময় কমানো, পড়াকে সহজ করা এবং গুরুত্বপূর্ণ বিষয়গুলো একটি জায়গায় গুছিয়ে দেওয়া।

আপনারা যদি বইয়ের প্রতিটি প্রশ্নের পেছনের টপিকটি বুঝে পড়েন, নিয়মিত অনুশীলন করেন এবং নিজের দুর্বলতাগুলো দূর করার চেষ্টা করেন, তাহলে বইটি আপনাদের চাকরির প্রস্তুতিতে গুরুত্বপূর্ণ ভূমিকা রাখবে বলে আমি বিশ্বাস করি।

কম পড়ুন, কিন্তু গুরুত্বপূর্ণ বিষয়গুলো ভালোভাবে পড়ুন। শুধু প্রশ্নের উত্তর নয়, প্রশ্নের পেছনের বিষয়টিও বুঝুন।

আপনাদের প্রস্তুতির পথচলা সহজ হোক, পরিশ্রম সফলতায় রূপ নিক—এই প্রত্যাশা রইল।

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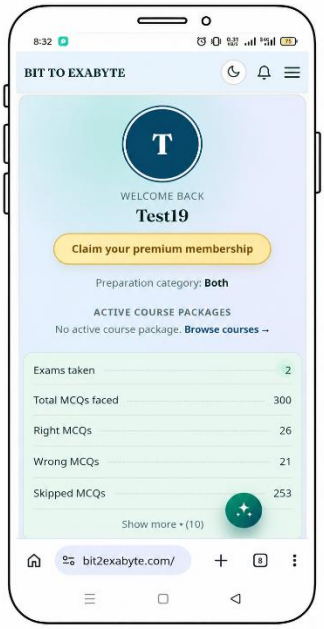

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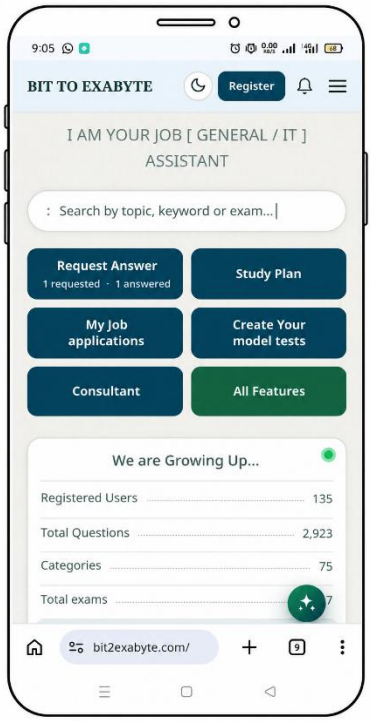

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9. Requlal Important Post
10. Study plan by Admin
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Topic-wise Organized Question Index

Chapter 0:

Previous All Questions of All Chapters(page 1 to 55)

01	All questions of All years (Chapterwise) To find answers , visit our website (www.bit2exabyte.com) Answer will be uploaded gradually.

Chapter 01:

DBMS, SQL, Database Design & Transactions

Q. No.	Question / Topic (Section 2 page 1- 83)
01	SQL: highest salary, second-highest salary, duplicate rows
02	ACID properties in DBMS
03	Normalization: 1NF, 2NF, 3NF, BCNF; functional, partial and transitive dependency
04	DBMS keys: primary, candidate, super, foreign and composite; disadvantages of indexing
05	SQL: Book and Author JOIN with country and year filter
06	Draw an ER Diagram for a Library Management System with the following requirements:
07	Differentiate Among Database, Data Warehouse, and Data Mining with Real-World Examples
08	Triggers in DBMS with SQL example
09	Draw and Explain the Complete ATM Transaction Architecture from the Customer to the Bank Server
10	Database relationships; use case diagram; ER diagram for e-commerce
Descriptive Part	**DDL, DML, DQL, DCL, TCL and other major SQL command categories with examples.**

Chapter 02:

Computer Networking, IP Addressing & Subnetting, TCP, Protocols

Q. No.	Question / Topic (page 84 – 197)
01	OSI model: layer functions and protocols; OSI vs TCP/IP
02	Subnetting 192.168.10.0/24 into four subnets
03	Private vs public IP; why NAT is needed
	Difference Between IPv4 and IPv6
	SLAAC (Stateless Address Autoconfiguration) is an IPv6
	Identify which of the given IPv6 addresses
	Networking troubleshooting
	Open Shortest Path First (OSPF) at the network layer.

04	DNS name resolution process
05	Hub vs switch vs router
06	Wi-Fi, Bluetooth, and WiMAX.
07	192.168.1.0/27: subnets, hosts and first-subnet addresses
08	VLSM for 192.168.10.0/22 with five departments/ An enterprise
09	Network topologies compared; which is best
10	ARP working procedure
11	Commercial bank network diagram and firewall protection
12	HTTP request; GET vs POST; which is more secure
13	HTTP status codes 1xx to 5xx; why 404 is a client error
14	Wi-Fi, Bluetooth and WiMAX; world without them
15	Why packet switching suits the Internet
16	2 GB file over 500 Mbps: transmission, propagation delay and RTT
17	Handshaking; TCP three-way handshake; flow vs congestion control
18	Enterprise bank network design using the OSI model
19	Classful IP addressing: Class A to E
20	CRC remainder calculation; even parity error detection
21	Loopback IP; accessing 127.0.0.1:8080; special IP addresses
22	Important protocols and port numbers (MCQ)
23	10 TCP SEQUENCE NUMBER MATH QUESTIONS & DETAILED SOLUTIONS
Descriptive Part	**HTTP and HTTPS ports, advantages, disadvantages, important technical concepts from basic to advanced.**

Chapter 03:

C Programming & Problem Solving , OOP & Java

Q. No.	Question / Topic (page 197- 248)
01	C program: sum of digits
02	C program: factorial using loop and recursion
03	C program: reverse a string without library functions
04	C program: **array** operations — maximum, minimum, sum, average, search and reverse
05	C program: replace each alphabet with the next alphabet
06	C program: GCD using functions
07	Call by value vs call by reference; swap using pointers
08	Structure vs union and memory management
*8.1	C program: palindrome string or matrix addition
09	Header files and library functions; C uppercase-to-lowercase conversion
10	Type casting; output-tracing problems
	Predict the output

11	C program: star pyramid pattern
12	calculate the sum of the following series: 1 + 11 + 111 + 1111+ ..... up to N.

13	C increment and decrement expression output
	int a = 5, b = 18, c = 27;
	a = b++ + ++c;
	b = a++ - c--;
	c = a++ + b--;

14	Polymorphism: method overloading vs overriding
15	Inheritance; multiple inheritance in Java via interfaces
16	OOP bank account program in C++ and encapsulation
17	JVM vs JRE vs JDK
Descriptive Part	C Programming (String Management)

Chapter 04:

Computer Architecture, CPU & Memory Management (MM)

Q. No.	Question / Topic (page 249- 296)
01	Average Memory Access Time (AMAT) with cache hit rate
02	CPU functions; ALU vs CU vs registers; BIOS vs UEFI; firmware; cache vs RAM; DRAM vs SRAM
03	Page vs frame; paging and fragmentation; page and frame bit calculation
04	8-bit 2's complement: 120 + (-45), overflow check
05	Types of ROM; SRAM vs DRAM
06	Maximum memory with a 20-bit address bus
07	Instruction pipelining; five-stage pipeline; speedup calculation; graph concept comparisons
08	Logical and physical address bits: 512 pages, 128 frames and 2 KB page
Descriptive Part	Memory management including paging, frames, pages, page tables address translation fragmentation

Chapter 05:

Operating Systems & Process Management

Q. No.	Question / Topic (page 296- 338)
01	Deadlock, four necessary conditions, prevention vs avoidance
02	Banker's algorithm: safe state and safe sequence
03	Process vs program; process state diagram
04	Virtual memory; page fault sequence
05	Memory management with 8 GB RAM, 24 GB virtual memory and 14 GB demand

06	Preemptive vs non-preemptive priority scheduling
07	Short notes: process vs thread, paging vs segmentation, virtual vs physical memory, deadlock vs starvation, multiprogramming vs multitasking, context switching and kernel
08	CPU scheduling: FCFS, SJF and preemptive priority with Gantt charts
09	Logical and physical address bits: 512 pages, 128 frames and 2 KB page
10	Linux file permissions and chmod
11	Write the Linux command(s) to: • Create an empty file named student.txt. • Rename it to student_info.txt. • Create a directory named CSE. • Move into the CSE directory.

Chapter 06:

Data Structures, Trees, Heaps & Graphs

Q. No.	Question / Topic (page 239- 372)
01	Min heap construction: (35, 12, 43, 8, 51, 20, 5); min vs max heap
	n array of 6 elements and sort it individually using Insertion Sort and Selection Sort.
02	Linked list vs array; types of linked list; insertion pseudocode
03	Graph Concepts ALL Directed Graph vs Undirected Graph
04	BFS and DFS traversal with example graph
05	BST construction and traversals; tree from traversals
06	Binary tree from inorder with postorder or preorder
07	Max heap insertion of 88, 100, 65
08	B+ tree of order 3; B-tree vs B+ tree
09	How binary tree is represented using an array.
10	Bipartite graph and its condition
11	Find the address of A[7][12] using Column Major Order and Row major index.

Chapter 07:

Algorithms & Complexity

Q. No.	Question / Topic (page 373- 394)
01	Fastest sorting algorithm; Quick Sort trace and complexity
02	Time complexity of nested loops; $= O(n^2 \log n)$
03	Complexity; time complexity of a double loop
04	Dynamic programming vs greedy algorithms

05	Knapsack with greedy and DP;
06	Tower of Hanoi for three disks
07	Search algorithm choice for one million employee records

Chapter 08:

Software Engineering & Testing

Q. No.	Question / Topic(page 395- 421)
01	Waterfall vs Agile model
02	Functional vs non-functional testing; black-box vs white-box testing
03	Waterfall vs Agile vs Spiral model
04	Software testing types: unit, integration, system, acceptance, smoke, regression, stress and performance
05	Feasibility study; TELOS model
06	Spiral model as risk-driven; Agile and Prototype models

Chapter 09:

Cybersecurity, Cryptography & Banking Security

Q. No.	Question / Topic(page 442- 445)
01	DoS vs DDoS attack
02	Zero-day vulnerability vs exploit; a bank's immediate response
03	Man-in-the-Middle attack and two countermeasures
04	CSRF, XSS and SQL injection; prevention
05	Social engineering; CERT; Bangladesh Bank heist
06	Digital signature generation and verification; CA and PKI
07	Symmetric vs asymmetric encryption; number of 128-bit keys

Chapter 10:

Computer Organization & Microprocessors

Q. No.	Question / Topic(page 445- 453)
01	Microcontroller vs microprocessor
02	8086 addressing modes
03	8086 effective and physical address calculation
04	RISC vs CISC

Chapter 11:

Digital Logic & Boolean Algebra ,Compiler concept & DFA,NFA, Automata, Formal Languages & Compiler Concepts

Q. No.	Question / Topic(page 453- 478)
01	K-map simplification: four-variable and three-variable
02	Truth table: tautology check All Terminology
03	Synchronous vs asynchronous counters; MOD-6 counter
04	Universal gates; XOR using NAND and NOR
05	8-bit 2's complement addition and overflow check
06	Latch vs flip-flop
07	DFA vs NFA; regular vs context-free language
08	Ambiguous grammar for id + id * id
09	NFA to DFA; DFA for exactly three 1s; DFA for substring 110; flip-flops for 10 states

Chapter 12:

Cloud Computing & Distributed Systems , AI, ANN, ML

Q. No.	Question / Topic(page 478- 516)
01	Cloud computing; IaaS, PaaS and SaaS
02	Confusion matrix: TP = 90, TN = 80, FP = 20, FN = 10
03	AI agent; narrow, general and super AI
04	Hadoop architecture; HDFS block and replica calculations
05	A* algorithm (in Bangla)
06	Supervised, Unsupervised, and Reinforcement Learning with Appropriate Examples.
07	Artificial Neural Network (ANN)? Explain How ANN Works with an Example.
08	Bias and Variance in Machine Learning? Explain Bias-Variance Tradeoff, Underfitting, and Overfitting
09	Genetic Algorithm (GA)? Explain How Genetic Algorithm Works

Chapter 13:

Version Control & APIs,Storage Systems & RAID P, NP, NP-Complete and NP-Hard

Q. No.	Question / Topic (page 517- 535)
01	RAID levels and how capacity is calculated

02	API; REST vs SOAP; API request flow to database
03	P, NP, NP-Complete and NP-Hard
04	Version control (Git): commit vs push

Chapter 14:

Electronics & Electric

Question No.	Topic(page 536- 554)
1- 13	1. What Is Salt in Hashing? Why Is It Needed? 2. What Is the Difference Between BJT and MOSFET? Which Is More Commonly Used in Modern Circuits? 3. Differentiate Between Stepper Motor and Servo Motor. 4. What Is PLE? Explain CMOS Technology and Its Advantages. 5. What Is a Loss Function in Machine Learning? Explain with Examples. 6. What Is MVC Architecture? Explain Its Components and Working Procedure. 7. What Is Ladder Logic? Explain Its Main Components and Applications. 8. Differentiate Between Monolithic Architecture and Microservices Architecture. 9. What Is Transfer Learning? Explain Its Working Procedure and Advantages. 10. What Is a Cobot? Differentiate Between a Traditional Industrial Robot and a Cobot. 11. Differentiate Between Single-Phase and Three-Phase Transformers. 12. What Is the Piezoelectric Effect? Explain Its Types and Applications. 13. What Is Power Factor? Explain Its Types, Causes, Effects, and Improvement Methods. 14. What Are Kirchhoff's Laws? Explain Kirchhoff's Current Law (KCL) and Kirchhoff's Voltage Law (KVL) with Appropriate Examples.

Chapter 15:

Math (22)- CSE / IT Exam Related

Question No.	Topic (page 555- 563)
Math-01	Bayes' Theorem (Conditional Probability)
Math-02	Bayes' Theorem (Conditional Probability)
Math-03	Basic Probability
Math-04	Bayes' Theorem (Conditional Probability)
Practice maths	1-17

Chapter 16:

Aptitude Question Pattern- CSE / IT Exam Related Exam

Question No.	Topic(page 563- 576)
Aptitude-01	C Programming – File Handling, Structure, File I/O and CGPA Calculation
Aptitude-02	DBMS – SQL Queries, INNER JOIN, GROUP BY, Aggregate Functions and Subqueries
Aptitude-03	OOP (Java) – Inheritance, Bank Account Management and Method Implementation
Aptitude-04	MS Excel – IF, SUMIFS, COUNTIFS, AVERAGEIFS, VLOOKUP, HLOOKUP, XLOOKUP, UNIQUE, Sorting and Filtering

Chapter 17:

Miscellaneous (576 – 650)

01	50th BCS written Question Solution
02	49th BCS MCQ Questions and Solution

Chapter 0
QUESTIONS BANK (PREVIOUS ALL YEARS)

Previous Questions

Computer Fundamentals and Computer Architecture

1. What is Computer Generation? Describe the characteristics of different generations of computers? *[18th NTRCA School 2024]*
2. What is OCR? Write down the difference between OCR and OMR. *[NPCNL JAM 2022]*
3. Name and define the components of a computer system. Mention two optical input devices. *[BPSC ADA 2022]*
4. What do understand by the resolution of computer screen? *[BPSC AP 2022]*
5. What are the components of a Micro-computer system? *[BPSC ADA 2022]*
6. Explain Impact Printer Non-impact printer. *[Bank SO(AME) 2021]*
7. Distinguish between OMR and MICR. *[BB AME 2016]*
8. Suppose you are entering data into computer but facing some problem with your monitor. You need to buy a new monitor. What factor should you consider in case of monitor? *[BB AME 2016]*
9. Write down the difference between Serial Port and Parallel Port. *[DESCO SAE 2023]*
10. Differentiate among Core Intel i3, i5 and i7 processor. *[Combined Bank SO(IT) 2023]*
11. **Difference between SAS and SATA. Which one is best server?** ***[PBL HE 2023]***
12. "Pentium processor has a superscalar architecture." Explain the meaning of statement. *[MM AP 2017]*
13. What is the difference between System Software and Application Software? *[NPCNL JAM 2022, 45th BCS (General) ICT 2024, MM AP 2017, BB AME 2016]*
14. একটি কম্পিউটারের BIOS সিস্টেমের এর মূল ভূমিকা কী? *[45th BCS (General), ICT 2024]*
15. **Explain BIOS in Server. How does affect booting configuration in Hardware maintenance.** *[RAKUB ANSE 2023]*
16. Describe the booting process in windows system. *[PBL HE 2023]*
17. What is BIOS? *[EGCB SAE(ICT) 2023]*
18. What is platform independent software discuss with example? *[Combined Bank SO(IT) 2023]*
19. Software বলতে কী বোঝায়? উদাহরণসহ System Software and Application Software-এর সংক্ষিপ্ত বর্ণনা দিন? *[40th BCS 2021]*
20. What is the function of GPU? *[BPSC AP 2022]*
21. Typical মাইক্রোকম্পিউটারে কী কী বাস থাকে। একটি মাইক্রোপ্রসেসর এর সাথে RAM, ROM এবং I/O এর কানেকশন বাস এর মাধ্যমে দেখাও। *[BPSC SAE 2021]*
22. What is computer bus? What is the unit of measurement of speed of computer bus? Describe about various types of computer bus. *[BKKB AP 2017]*
23. **Write down the necessary components of a USB bus with block diagram.** ***[ICT Ministry AP 2017]***

24. MS-Excel এর IF Function ব্যবহার করে A1, B1, C1 থেকে ছোট সেল খুঁজে D1 এর মধ্যে রাখার সমীকরণ লিখ। *[PGCB SAE (CSE) 2021]*
25. **What is pipelining? How does pipeline implementation make faster instruction execution? *[38th BCS]***
26. How does an interrupt can be enabled? What are the steps that occur when an interrupt is processed? *[38th BCS]*

Previous Questions — C Programming

1. What is the difference of the following: getc (), getchar (), getch () and getche ()? [*45th BCS, ICT 2024*]
2. What is the difference between Null and Void? [*BCC AP 2023*]
3. What is the difference between sizeof c+1 and sizeof (c+1)? [*BPSC AP 2023*]
4. **Local variable এবং Global variable এর মধ্যে পার্থক্য লিখুন। [*17th NTRCA(CSE) 2023*]**
5. Write about the syntax of function. [*BARC Programmer 2023*]
6. **Distinguish between Compiler and Interpreter with example. [*BPSC ADA, AP 2022; 40th BCS, PGCB SAE (CSE) 2021; 40th BCS 2020; BCC Programmer 2019*]**
7. Formatted Input/output Statement কাকে বলে? Key-Board থেকে কিভাবে input নেয়া যায়? %d এর অর্থ কী? [*BPSC ANE 2020*]
8. What are the main objectives of structured programming? Write two advantages of structured programming. [*SPARRSO 2020*]
9. Difference between getch () and getche (). [*BBL AM (ICT) 2019*]
10. Write down the role of a linker. [*BUET M.Sc. May-2016*]
11. **How can we initialize 1-D array? How can we pass the array to a function in C? [*45th BCS, CSE 2024*]**
12. if.....else statement এর format লিখ। [*BPSC ANE 2020*]
13. What is looping? Why use looping? Give a proper example. [*BCPSC AP 2018*]
14. What is the basic difference between looping and branching? [*BCPSC AP 2018*]
15. **Write a simple program in C to swap two integer values using 'Call by value'. [*BPSC AP 2023*]**
16. **Differences between 'Call by Value' and 'Call by Reference'. [*BPSC AP, 17th NTRCA(ICT) 2023; BPSC ADA, AP 2022; PSB AP 2018*]**
17. উদাহরণসহ recursion ব্যাখ্যা করুন ও Parameter Passing ব্যাখ্যা করুন। [*17th NTRCA(ICT) 2023*]
18. Difference between Array and Structure data type. [*BPSC AP 2022; BPSC AE 2022; BPSC AP, BOF AE(CSE) 2021*]

19. What do you mean by recursion? Calculate factorial function using recursion with C programming code. [*45th BCS ICT 2024; Milk Vita AM(CSE) 2023; BPSC AP 2022; BPSC AP, ANE 2020*]
20. Write a function to find the smallest element from an array. [*Combined Bank AP 2023*]
21. **What is the difference between array and pointer? [*BPSC AME 2021*]**
22. **Difference between ++i and i++.** [*17th NTRCA(ICT) 2023; NU AP 2020*]
23. What is file pointer in C? [*BBL AM (ICT) 2019*]
24. The maximum subarray is the task of finding a contiguous subarray with the largest sum within a given one dimensional array of numbers. Suppose the array is:

    A: [-2, 1, -3, -1, 2, 1, -5, 4] [*BPDB AE(CSE) 2023*]

25. Find the output of following program: [*BGDCL AE (CSE) 2021*]

```
int i, j, p, sum;
sum = 0;
for(i = -1, p = 0; i <= 10; i = i + 2) {
    p = i * i;
    if(i > 5)
        break;
    sum = sum + (i + p);
    printf("i=%d, p=%d, sum=%d\n", i, p, sum);
}
printf("\n Outsite Loop, i=%d, p=%d, sum=%d\n", i, p, sum);
return 0;
```

26. Find the output of following program: [*PSB AP 2018*]

```
int main() {
    int n = 10;
    for(;;)
        printf("%d", n);
    return 0;
}
Or
int main() {
    int i = 2, j = 2;
    while(i ? --i : j++)
        printf("%d", i);
```

```
    return 0;
}
```

27. Find the output of following program: [*PSB Programmer 2018*]

```
int main() {
    char str[120] = "Digital Bangladesh";
    int n;
    n = strlen(str);
    str[4] = '\0';
    printf("%s", str);
    return 0;
}
Or
int main() {
    int i;
    for(i = 0; i < 5; i++) {
        if(i == 3)
            continue;
        printf("%d\n", i);
    }
    return 0;
}
```

28. After compilation and execution, what will be output in the following code: [*DPDC JAM (ICT) 2020*]
29. What will be the outcome of the following conditional statement if the value of variable s is 10?
30. What would happen to X in this expression: x+=15; (assuming the value of X is 5)
31. Find the output from the following: take input and looks the output: [*BGDCL, AM(CSE)2024*]

```
#include <stdio.h>
int reverseNumber(int num) {
    int reverse = 0;
    while (num != 0) {
        reverse = reverse * 10 + num % 10;
        num /= 10;
    }
```

```
    return reverse;
}
int main() {
    int input, output;
    printf("Enter a number: ");
    scanf("%d", &input);
    output = reverseNumber(input);
    printf("Input: %d\n", input);
    printf("Output: %d\n", output);
    return 0;
}
```

32. Write a C program to print Fibonacci series without using recursion and using recursion. [*17th NTRCA(CSE) 2023; BB AP 2016*]
33. Write a C program to find nth Fibonacci number using Recursion. [*KGDCL AE(CSE) 2021*]
34. Given two integers A and B as input write a program to compute the least common multiple of A and B. [*BB AP 2023*]
35. Write a c program to reverse given number.
36. Write a program to reverse string without using library function. [*BREB AP 2023; Combined 2 bank, ADA 2022*]
37. **Write a program in any language to find the sum of rows and columns of a m x n matrix, where m and n is taken input from the user. Give the output in the following format:** [*Combined Bank, SO(IT) 2024*]
38. Write a program in any language that takes two matrices A and B as inputs ensure your code handles matrices of different dimensions-
    A) Find matrices C that is multiplication A and B.
    B) Find average in A and B.
    C) Max from matrices C [*Combined Bank SO(IT) 2023*]
39. Write a C Program Find sum of the series: 1+2+4+7+11+.....+N [*Combined Bank, AP 2024*]
40. Write a program from the following series: $e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots\ldots\ldots$ [*SB PCL, ADBA 2024*]
41. **Write a program in C++ to calculate the sum of the series: 1+(1+2)+(1+2+3)+....+(1+2+....+n).** [*MM AP 2017*]
42. Write a C program to find the length of a String without using function strlen(). [*BPSC AME 2021*]

Previous Questions

Object oriented Programming

1. What is Polymorphism? Discuss about different types of Polymorphism with example? [*Combined Bank, AP 2024*]
2. **Write the differences between structured programming and object-oriented programming.** [*45th BCS CSE 2024*, *Bank SO(AME) 2021*]
3. Write down the advantages of OOP over traditional structured programming language. [*Combined Bank Officer(IT) 2023*]
4. What is the diamond problem of multiple Inheritance in C++? [*BPSC AP 2023*]
5. কী কী ধারণার উপর ভিত্তি করে OOP প্রতিষ্ঠিত? ধারণাগুলো ব্যাখ্যা করুন। [*17th NTRCA(CSE) 2023*]
6. উদাহরণসহ Class এবং Object এর মধ্যে পার্থক্য ব্যাখ্যা করুন। [*17th NTRCA(CSE), (ICT) 2023*]
7. **Inheritance কী? উদাহরণসহ ব্যাখ্যা করুন। [*17th NTRCA(CSE) 2023*]**
8. **Write down the Principle of OOP. What is Polymorphism? Write the name of 3 OOP language.** [*DESCO SAE 2023*, *40th BCS 2021*]
9. How many classes can be used in Hybrid Inheritance? [*BCC AP 2023*]
10. What is virtual function with example? [*BITAC AP 2023*]
11. Define Method Overloading and Method Overriding with examples. [*BPSC AP, 17th NTRCA(ICT) 2023*, *Bank SO(AME)*, *RAKUB Programmer*, *BPSC AME 2021*, *NU AP 2020*]
12. What is Polymorphism? Java language এর আলোকে ব্যাখ্যা কর। [*BTCL, JAM 2022*]
13. What are the various Access Specification in C++? Explain their purpose with are example. [*BPSC, ADA 2022*]
14. Object Oriented Programming এর যেকোনো দুটি বৈশিষ্ট্য উদাহরণসহ ব্যাখ্যা করুন। [*BPSC AP 2021*]
15. Object Oriented Programming এ Static binding and Dynamic binding কি? ব্যাখ্যা করুন। [*BPSC AP 2021*]
16. Write the definition of Inheritance, Polymorphism with coding example. [*Combined Bank, AP 2021*]
17. Procedural Oriented ও Object Oriented Programming Languages এর মধ্যে পার্থক্য কি? উভয় Language এর ২টি করে উদাহরণ দিন। [*BPSC AP 2021*]
18. **Inheritance is one of important issues for any object oriented programming language. The main advantage of Inheritance is the ability to reuse the code. Explain in brief different types of Inheritance.** [*Combined Bank, Officer(IT) 2020*]
19. Briefly Describe Abstraction, Encapsulation. [*BCC Programmer 2019*]
20. What do you mean by Polymorphism and Inheritance in object oriented programming (OOP)? Give appropriate example. [*PBL SO 2018*]
21. Pointer কী? Pointer ব্যবহারের সুবিধাসমূহ লিখুন। [*17th NTRCA(CSE) 2023*]
22. What is constructor function? Write the properties of it. [*WZPGCL AE(CSE) 2023*]

23. পয়েন্টার কী? Malloc() এবং Calloc() এর মধ্যে পার্থক্য লিখুন। [*17th NTRCA(ICT) 2023*]
24. What is the constructor invoked in OOP? [*BPSC, AP 2022*]
25. Why are constructor and destructor functions used in object oriented programming? Give examples of each function in C++ or java language. [*BPSC SAE 2021*]
26. **What is main difference Destructor and constructor with example?** [*PSB Programmer 2018*]
27. Write the difference between throw and throws using Exception handling? [*PBL SO 2018*]
28. **What is Multithreading programming? Why Multithreading used in programming?** [***Combined Bank, AP 2024***]
29. **Write down the difference between Multitasking and Multiprocessing.** [*DESCO SAE 2023*]
30. How does dynamic programming relate with divide and conquer approach? [*BPSC AP 2023*]
31. Write down the difference between Divide and Conquer and Dynamic Programming. [*WZPGCL AE(CSE) 2023*]
32. What syntax is used for calling static methods in class? [*BCC AP 2023*]
33. What is the output of code snippet? [*BCIC, AP 2022*]
34. Both the algorithm the Divide and Conquer and Dynamic Programming solve a problem by breaking it into smaller problem instances and by solving them. What are the difference between their two techniques? [*BCC AP 2021*]
35. Object oriented programming- এর প্রেক্ষিতে function overloading বলতে কী বোঝায়? Function overloading এর একটি উদাহরণ দিন। [*40th BCS 2020*]
36. What is the difference among String, String Buffer and String Builder? [*DBBL PO 2017*]
37. **Suppose you've a method name "totalAmount" and there three properties (transactionName, transactionType, amount). Write down the full code using JAVA where totalAmount method return total balance after debit or credited.** [*PBL SO 2018*]
38. Write a program using any programming language that reads five numbers from keyboard and display the smaller, larger and average of those numbers. [*BDB SO (IT) 2017*]
39. Write a java program based on following conditions: There is one Circle class and one Cylinder Class. Circle class has an area function. Cylinder class has to calculate the circle area at the base and height of its own (Cylinder area = Circle area*height). Use inheritance to calculate Volumn of Cylinder. [*DBBL PO 2017*]
40. Write down a method to find out how many times an object has been instantiated in Java? [*BUET M. Sc. May 2016*]
41. Define types of processor for the following language: Python, C, C++, Java. [*BUET M. Sc. May 2016*]

Previous Questions	Cyber Security And Cloud Computing Big Data, Data Mining

1. What is Cyber security? [*Combined Bank AME/AHE, SO(IT) 2023*]
2. **What is CIA Triad?** [*Teletalk AM(IT), EGCB SAE (ICT) 2023*]
3. What are the differences among Virus, Worms and Trojan horse? [*45th BCS, CSE 2024*]
4. Explain XSS and CSRF (how do you prevent these attacks). [*Titas Gas AE(CSE) 2024*]
5. Let you procure a microfinance application and host it in your office's data center. What kind of cyber-security threats should you be aware of and what steps would you take to mitigate the threats? [*Combined Bank, SO(IT) 2024*]
6. Write down the top 10 cyber-attack. [*Combined Bank AME/AHE, SO(IT), Officer(IT) 2023*]
7. Spyware এর কাজ কী? উদাহরণ দিন। [*45th BCS (General), ICT 2024*]
8. Discuss about Ransom ware and DDoS attack. [*Combined Bank SO(IT) 2023*]
9. Explain buffer overflow attack with an example. [*BTCL AME 2023*]
10. **Write the difference types of Web application attacks? [*MoL AME 2023*]**
11. **What is SQL Injection? How to Prevent against SQL Injection Attacks?** [*SGFL AE(IT) 2023; RAKUB Programmer, ME, SPCBL AME 2021, BTV AP 2019*]
12. Describe a man-in the middle attack on the Diffie-Hellman key exchange protocol in which the adversary generates two public key pairs for the attack. [*BB AP 2023*]
13. **Write two differences between SQL Injection and cross site scripting (XSS).** [*BCIC, AP 2022*]
14. What is DDoS and SQL Injection attack? [*SBL Officer(IT) 2021*]
15. একটি Virus ও Ransomware এর নাম লিখ? [*BTCL, JAM 2022*]
16. **Malware বলতে কী বুঝানো হয়? উদাহরণসহ সংক্ষেপে বর্ণনা করুন।** [*40th BCS 2021*]
17. If you downloaded the email, you will be able to face the problem. Which attack do you face? [*BCC AP 2023*]
18. Difference among Black Hat hacker, Grey hat hacker and white hat hacker. [*Combined Bank Officer(IT) 2023*]
19. **Difference between active and passive attack. [*BEPZA Programmer 2023*]**
20. **Difference between Conventional signatures & digital signatures?** [*45th BCS (General), ICT 2024*]
21. Difference between Digital signature and Digital certificate. [*Combined Bank Officer(IT) 2023*]
22. What is digital signature? Where is it used? [*BPSC AE 2022*]
23. What is a digital signature? Describe its role in digital security? [*BPSC AP 2022*]

24. Write down the purpose of Certification Authority (CA) in Digital Signature. [*BPSC SAE 2021*]
25. Write down the difference between Authentication and Authorization. [*40th BCS 2020*]
26. What is public key encryption? Explain digital signature with example. [*ICT Ministry AP 2017*]
27. Difference between symmetric and asymmetric key encryption. [*BEPZA Programmer 2023*]
28. **What is Symmetric and Asymmetric Encryption? Explain with example.** [*NPCBL ET(Soft); WZPGCL AE(CSE) 2023, BPSC SAE 2021*]
29. Distinguish between Symmetric Encryption and Asymmetric Encryption. Give some examples of encryption algorithm. [*Rupali Bank ANE 2023*]
30. What is meant by Encryption and Decryption? [*Combined Bank AME/AHE 2023*]
31. **What is Cryptography? Difference between Symmetric and Asymmetric encryption with example. Draw and design public key encryption using Hash function. Draw a diagram for e-commerce online transactions.** [*Combined Bank SO(IT) 2023*]
32. What are the different types of ciphers in cryptography? What are the factors to be considered for cryptographic strength? [*Rupali Bank ANE 2023*]
33. How do you define 2 factor authentication? Give example. [*BPSC AP 2023*]
34. অথেনটিকেশন বলতে কী বোঝায়? টু-ফ্যাক্টর অথেনটিকেশনের বর্ণনা দিন। [*45th BCS (General), ICT 2024*]
35. **Identify the type of algorithm? (i) MD5 (ii) AES (iii) RSA (iv) Diffie-Hellman** [*BAPEX AGM(ICT) 2023*]
36. Describe RSA Algorithm and how it works? [*Teletalk AM(IT) 2023*]
37. **Briefly describe the relationship among threat, zero days vulnerability and attack. Give examples.** [*BPSC AME 2021*]

Cloud computing

1. Cloud computing কী? উহার বৈশিষ্ট্য ও সুবিধা বর্ণনা করুন। [*17th NTRCA(CSE) 2023*]
2. What is Cloud Computing? Write its advantages and Disadvantages? [*NPCNL, JAM 2022*]
3. Cloud Computing এর সার্ভিসগুলো লিখুন। [*BPSC AP 2021*]
4. Write the three basic function of cloud services? [*BOF AE(CSE) 2021*]
5. Define cloud computing? What is the benefit of cloud computing? [*BLPU AP 2018*]
6. Write ten sentences on "Big Data". [*MRA SCO 2023*]
7. **Big data বলতে কি বুঝায়? Big data এর বৈশিষ্ট্যগুলো লিখুন।** [*BPSC AP 2021*]
8. Your bank wants to transform your full data center into a cloud. Now sketch your strategy and plan to implement this procedure. [*Combined Bank, AME/AE(IT) 2024*]

9. Your bank wants to secure an e-banking online system and wants to configure a web server in your data center. What kind of tools and technology do you use for this? [*Combined Bank, AME/AE(IT) 2024*]
10. What are the challenges in optimizing energy efficiency of data centers? Explain! [*BB AP 2023*]
11. Discuss server maintenance best practices, including routine tasks like cleaning, monitoring, and applying security patches. How do these practices contribute to server longevity and performance? [*Rupali Bank ANE 2023*]
12. Define a virtual machine with a neat diagram, explain the working of VM. What are the benefits of a VM? [*BB AP 2023*]
13. What do you mean by national data center? [*BPSC, AP 2022*]
14. Explain the component of Data Center. [*ABL SO (IT) 2017*]
15. To maintain a data center cooling system sometimes where you need a DC generator. Which type of generator do you prefer based on fuel type generator type, cost, energy, and budget? [*Combined Bank, AME/AE(IT) 2024*]

Previous Questions — Database and SQL

1. Discuss about different types of relations in DBMS. *[Combined Bank, AP 2024]*
2. সাধারণ ফাইলভিত্তিক সিস্টেমের চেয়ে DBMS এর সুবিধা কী কী? *[17th NTRCA(ICT) 2023]*
3. What is Database? *[EGCB SAE(ICT) 2023; BKKB AP 2017]*
4. What is the degree of relation in DBMS? *[BCC AP 2023]*
5. What are the ACID properties of transaction to ensure data reliability and integrity? *[Milk Vita AM(CSE), BPSC AP 2023; BBL AM (ICT) 2019]*
6. ডাটাবেস ট্রানসেকশনের ACID Properties সম্পর্কে লিখুন। *[17th NTRCA(ICT) 2023]*
7. Describe the advantages and disadvantages of DBMS-provided and application provided security. *[BPSC, AP 2022]*
8. What is distributed database? *[Combined 2 bank, ADA 2022]*
9. Write difference between relational database and NoSQL database. *[SBL Officer(IT) 2021]*
10. While converting E-R diagram into Tables, how is a Many-to-many relationship set between entities A and B is converted into database tables? *[BPSC SAE 2021]*
11. DBMS বলতে কী বোঝানো হয়? DBMS শ্রেণিবিন্যাস বর্ণনা করুন। *[40th BCS 2020]*

12. Explain the concept distributed DBMS. What are the features of DBMS? *[BB AME 2019]*
13. What is DBMS? Write the full meaning of DDL and DML. *[BKKB AP 2017]*
14. Product (pname,price,category,maker),
    Purchase (buyer,seller,stock),
    Company(cname,country),
    Person(per-name, address, phone).
    Here in Product table make is similar to cname, here buyer and seller in Purchase table is similar to per-name in Person table, Draw the ER diagram of from the above information:
    a. Select person name who bought American category product
    b. Find Sum of all product and Sum of All sales product according to country of origin. *[NWPGCL, AM(ICT) 2024]*
15. Query's: Employee & department table given:
    a. Write the employee name who got same salary named Rahim but not same job of Rahim.
    b. Write the employee's name who's average salary is more than company's average salary. *[BGDCL, AM(CSE)2024]*
16. From an Employee table. Write SQL statement statement according to the following question:
    (i) Find out the employees who join the same date
    (ii) Find those employees whose salary greater than 8,000 and Less than 25,000. *[BRDB AP 2023]*
17. Database Query:
    Employee (ID, First_name, Last_name, Joining_date, Salary)
    Employee_Info (Emp_ID, Designation)
    a. Create both tables
    b. Show department-wise min, max, average salary of employees
    c. Show details of employees joined before February 2023. *[MRA SCO 2023]*
18. Suppose that we have a relational database with the following table. Underlined one represent primary key:
    Movies (mid, title, year)
    People (pid, name)
    Genres (gid, genre)
    HasRole (pid, mid, role)
    Has Genre (gid, mid)

Write a SQL query to return the number of movies that are romantic comedies. *[BB AP 2023]*

19. Write following EMPLOYEE database table write an SQL query to find employee who work is a department where the average salary is lower than the average salary all the department..... *[Exam name/year omitted in source]*
20. Consider the two schema

    employees (id, first_name, last_name, designation,
    joining_date, salary, dept_id) and
    department (dept_id, dept_name).

    Where detp_id is forgeign key. Find the first_name and department name whose salary is maximum. *[BIWTA AE(CSE) 2023]*
21. Consider the Schema

    employee(id, name, salary),
    equipment(id, name, price),
    hire(employee_id, equipment_id);

    Write the SQL query to show the name of employee who borrow the maximum equipment? *[BAPEX AGM(ICT) 2023]*
22. Consider the employee tables: Create a SQL view that shows the details of Employee information who have the salary equivalent to the maximum, minimum and average salary of employee. *[Milk Vita AM(CSE) 2023]*
23. Analyze the following code:

```
SELECT department_name, AVG(salary) as average_salary
FROM employees
JOIN department d ON e.department_id = d.department_id
WHERE salary > (SELECT AVG(salary) FROM employees )
GROUP BY department_name
HAVING COUNT(*) > 2
ORDER BY average_salary desc
```

    [Combined Bank Officer(IT), Rupali Bank ANE 2023]
24. Employee table হতে Employee_id, Employee কে খোঁজে বের করার SQL Command লিখ যাদের গড় salary 2000 উপরে। *[BTCL, JAM 2022]*

25. SQL Query for finding Dept names for departments Find out the employees whose salaries are greater than the salaries of their managers. *[NESCO AM(ICT) 2021*
26. Suppose, 'Employee' table (emp_id, emp_name, dept_id, salary) and 'Department' table (dept_id, dept_name, increment_dept). Create a tigger to increment the salary of the employee by 10% whose salary is above 30000. *[PGCB AE (CSE) 2021]*
27. Below tables are given, Employee (employee_id, name, salary, department) Leave (employee_id, date, reason, no_leaves) Holiday (Date, description):
    (i) Write query to show all employee's leave count.
    (ii) Write query to show employees who are in 'HR' department and have taken at least 5 leaves. *[RBL ANE 2021]*
28. Find the Query for the Instructor table:
    a) Find the average salary of instructors in each department.
    b) Find the names and average salaries of all departments whose average salary is greater than 42000.
    c) Find names of instructors with salary greater than that of some (at least one) instructor in the CSE department. *[NRCC AP 2021]*
29. Write a SQL query to find those employees who report that manager whose first name is 'abc'. Return first name, last name, employee ID and salary. *[PGCL SAE (CSE) 2021]*
30. emp [e_id, e_name, dept_id, salary, DOB], dept [dept_id, city, dept_name]; প্রত্যেকটি Department এর নাম এবং ঐ Department এর employee দের গড় Salary দেখার SQL Query লিখ। *[NESCO JAM(ICT) 2021]*
31. Given Table:
    Project (Project_id, Project_name, Manager_name)
    Location (location_id, Location_name, project_id)
    Employee (Employee_id, Employee_Name, Location_id, Joning date, Salary)

Write a query to show project_name, Location_name, Total_salary of each projects employee who joined before 'January 2021' *[APSCL AE (ICT 2021)]*

32. Database table by name Loan Records is given below:

Borrower	Bank_Manager	Loan_Amount
Rahim	Shuvo	1000.00

Shamim	Rasel	500.00
Mamun	Shuvo	7000.00

What is the output of the following SQL query?

SELECT count (*) FROM (
(SELECT Borrower, Bank_Manager, FROM Loan_Records) AS S NATURAL JOIN
(SELECT Bank_Manager, Loan_Amount FROM Loan_Records) AS T);
[BAUST AP 2021]

33. Consider the following Schemas-

Movies (title, year, length, genre, studioName, producerCert)
starsIn (movieTitle, movieYear, starName, salary)
MovieStar (name, address, gender, birthdate)
MovieExec (name, address, producerCert, netWorth)
Studio (name, address)

Write SQL queries for the following:

(a) Find the address of a studio named MGM
(b) Find the number of movies that was not produced by "MGM" *[BPSC AME 2021]*

34. Given a database schema and worker table with fully code: Now writes SQL Query from the following questions.
    - Write a query to get distinct name
    - Write a query to get the first three letter of first_name column from worker table. *[DPDC 2020]*

35. SQL Query:
    (i) Commission greater than 10% *[NU AP 2020]*
    (ii) Remove duplicate data from table: *[NU AP 2020]*

36. Database Query: Given two table

COURSE (Course_ID, Course_name, Chief_ID) and
INSTRUCTOR (Instructor_ID, Course_ID, Salary, Joining_date).

Write down database query Average salary for different courses. *[NACTAR 2020]*

37. Design a database of student with the gpa of a university. Find the top 10% gpa holder from the different department of the university. *[5 Bank AME 2019]*
38. Write a query to select top 10% row from grade table. *[CB AP 2018]*
39. What is the SQL command used to fetch first 3 characters name from employees? *[BCPSC AP 2018]*

40. Write an SQL query to insert a tuple in the table: Employee (ID, Name, Designation, and Salary). *[NESCO AM (ICT) 2018]*
41. Suppose you've two table (Employee, Department) in a Database and Employee table three cell (emp_name, dept_id, salary) also Department table two cell (dept_id, dept_name), now update the salary 10% increase value from Department table. Give the appropriate example. *[PBL SO 2018]*
42. Given two tables are

    employee (id, name, salary, dept_id) and
    department (dept_id, dept_name),

    write SQL to find MAX salary and average salary of specific department. *[DBBL PO 2017]*
43. What is the SQL query for showing only the duplicate lists in student (id, name, gpa) table? *[ABL Officer (ICT) 2017]*
44. নিচের Table টি তৈরি করার SQL কমান্ড লিখুন।

    student_info (std_id, name, department, phone_number)

    a. Table টি তে ২টি record (insert) প্রবেশ করার SQL কমান্ড লিখুন।
    b. Table টি থেকে CSE বিভাগের ছাত্র/ছাত্রীদের নামের তালিকা বের করার SQL command লিখুন। *[BPSC AP 2021]*
45. What is a weak entity for data modeling using the entity relationship model find out any weak entity and it's identify relationship for the school database? Which of the following table?

    Student (student_id, student_name, admission_year)
    Teacher (teacher_id, teacher_name, teacher_joindate)
    Course (course_id, subject_name, credit) *[BCC AP 2021]*

Previous Questions — Operating System, Deadlock Paging, linux

1. Define deadlock in operating system. Draw a proper diagram to show a deadlock situation and discuss in brief. *[45th BCS, CSE 2024]*
2. Give the necessary conditions for deadlock to occur. Is it possible to have deadlock involving only a single process? Explain your answer. *[Combined Bank, Officer (IT) 2024]*

Chapter 01

DBMS, SQL, Database Design & Transactions

01 READ THE FOLLOWING TABLE

[আইটির সকল পরীক্ষায় SQL আসবেই। তাই কমন আনকমন সকল SQL পড়ার ট্রাই করবেন। আমি যেগুলো দিয়েছি সেগুলো অবশ্যই পড়বেন। DESCRIPTIVE PART এ আমি বেসিক থেকে ADVANCED পর্যন্ত SQL এর ব্যাখ্যা সহ অধ্যায় দিয়েছি, পড়বেন]

emp_id	emp_name	salary
1	Rahim	50000
2	Karim	70000
3	Jamil	90000
4	Salma	70000
5	Karim	7000

Given the **Employee (emp_id, emp_name, salary)** table, write an SQL query to find the highest salary.

Solution:

```
SELECT MAX(salary) AS Highest_Salary
 FROM Employee;
```

2nd highest salary. ***

```
SELECT MAX(salary) AS Second_Highest_Salary
FROM Employee  WHERE salary  < ( SELECT MAX(salary)  FROM Employee );
```

find the duplicate person or row. ***

```
SELECT emp_name, salary, COUNT(*)
FROM Employee
GROUP BY emp_name, salary
HAVING COUNT(*) > 1;
```

Practice Questions

1. Differentiate between the following SQL language categories:

   DDL , DML , DCL, TCL, DQL

2. Using Employee(EmpID, EmpName, DeptID, Salary) and Department(DeptID, DeptName, Location), write SQL queries to:

   a. Display employee names with department names.
   b. Show employees working in the IT department.
   c. Display all employees, including those without a department (LEFT JOIN).
   d. Display only departments that have employees.
   e. Count the number of employees in each department.

3. What is a transaction? Explain COMMIT and ROLLBACK.
4. A company maintains the following tables:

   Employee(EmpID, EmpName, DeptID, Salary)
   Department(DeptID, DeptName)
   Project(ProjectID, DeptID, Budget)
   WorksOn(EmpID, ProjectID, HoursWorked)

   Write SQL queries to:

   a. Display each employee's name, department name, project name, and hours worked.
   b. Find the department with the highest total project budget.
   c. Find employees who have never worked on any project.
   d. Display the total salary paid by each department.
   e. Find the employee who has worked the highest total number of hours across all projects.

5. **DELETE vs TRUNCATE vs DROP**
6. What are aggregate functions in SQL? Why are they used?Using the following schema:

Employee(EmpID, EmpName, DeptID, Salary)
Department(DeptID, DeptName)

Write SQL queries to:

a. Display the department name with the highest total salary.
b. Display the department name with the maximum number of employees.
c. Display the department whose average salary is the highest.

d. Display departments with no employees.

e. Display the overall company average salary along with each department's average salary.

Practice More examples. See previous questions for more.
If you need answer , go to our website (www.bit2exabyte.com) → Request Answer (Send Your Questions), Admin will provide direct answers or pdf. You may also browse our subject based resources.

02	What is ACID in DBMS? Explain Its Properties with Examples.

ACID is a set of four fundamental properties that ensure database transactions are processed reliably, consistently, and safely, even in the presence of system failures.

ACID stands for:

A – Atomicity
C – Consistency
I – Isolation
D – Durability

These properties are essential for systems such as banking, e-commerce, airline reservation, and online payment systems.

1. Atomicity

Atomicity means a transaction is treated as a single indivisible unit. It either completes entirely or does not happen at all.

Example

A bank transfers ৳5,000 from Account A to Account B.

Steps: Deduct ৳5,000 from A.

Add ৳5,000 to B.

If the system crashes after deducting money from A but before adding it to B, the transaction is rolled back.

Result: Either both operations succeed or neither occurs.

2. Consistency

Consistency ensures that every transaction moves the database from one valid state to another while preserving all integrity constraints.

Example

Suppose total balance is:

A = 10,000 B = 5,000

Total = 15,000

After transferring ৳2,000: A = 8,000 and B = 7,000

Total = 15,000

The total balance remains unchanged, so the database stays consistent.

3. Isolation

Isolation ensures that multiple transactions execute independently without interfering with each other.

Example

Two ATM users access the same account simultaneously.

Without isolation: Both may read the same balance and withdraw money incorrectly.

With isolation: One transaction finishes before the other proceeds, preventing inconsistent data.

4. Durability

Durability guarantees that once a transaction is committed, the changes remain permanent even if the system crashes.

Example

After an online payment is confirmed, the transaction is stored permanently.

Even if there is a power failure immediately afterward, the payment record is not lost.

ACID Properties

Property	Meaning	Example
Atomicity	All or nothing	Bank transfer completes fully or rolls back
Consistency	Maintains valid database state	Total account balance remains correct
Isolation	Transactions do not interfere	Two ATMs access the same account safely

Durability	Committed data is permanent	Payment record survives system crash

ACID properties ensure reliable transaction processing in DBMS. They maintain data integrity, prevent inconsistencies during concurrent transactions, and guarantee that committed data is safely stored even after failures.

03	What is normalization in DBMS? Why is it important? Differentiate among 1NF, 2NF, 3NF, and BCNF. What is functional, partial, and transitive dependency?

Normalization is the process of organizing data in a relational database to minimize **data redundancy** and eliminate **undesirable anomalies** (Insertion, Update, and Deletion anomalies). It divides large tables into smaller, well-structured tables and establishes relationships among them using keys.

The primary goal of normalization is to ensure that each piece of data is stored only once and that the database maintains consistency and integrity.

Why is Normalization Important?

1. Reduces data redundancy.
2. Eliminates insertion anomalies.
3. Eliminates update anomalies.
4. Eliminates deletion anomalies.
5. Improves data consistency.
6. Maintains data integrity.
7. Makes database maintenance easier.
8. Optimizes storage space.
9. Simplifies future modifications.
10. Improves overall database design.

Difference among 1NF, 2NF, 3NF, and BCNF

Normal Form	Condition	Removes
1NF (First Normal Form)	All attributes contain atomic (single) values; no repeating groups.	Repeating groups and multivalued attributes

2NF (Second Normal Form)	Must satisfy 1NF and every non-key attribute must be fully dependent on the whole primary key.	Partial dependency
3NF (Third Normal Form)	Must satisfy 2NF and no transitive dependency should exist.	Transitive dependency
BCNF (Boyce-Codd Normal Form)	Must satisfy 3NF and every determinant must be a candidate key.	Remaining dependency anomalies

Unnormalized Table

StudentID	StudentName	Course1	Course2
101	Rahim	C, C++	Java

Multiple values in one row violate **1NF**.

1NF

StudentID	StudentName	Course
101	Rahim	C
101	Rahim	Java
101	Rahim	C++

Only atomic values exist.

2NF — Second Normal Form

A table is in 2NF if:

1. It is already in 1NF, and
2. There is no partial dependency.

Partial Dependency

A non-key attribute depends on part of a composite primary key, rather than the whole key.

Example

Consider: Student_Course

Student_ID	Course_ID	Student_Name	Course_Name	Marks
S1	C1	Rahim	DBMS	80
S1	C2	Rahim	OS	75
S2	C1	Karim	DBMS	85

Primary Key = (Student_ID, Course_ID)

Functional dependencies:

- (Student_ID, Course_ID) → Marks
- Student_ID → Student_Name
- Course_ID → Course_Name

Student_Name depends only on Student_ID, and Course_Name depends only on Course_ID. Therefore, there are partial dependencies, so the table is not in 2NF.

Convert to 2NF

Student

Student_ID	Student_Name
S1	Rahim
S2	Karim

Course

Course_ID	Course_Name
C1	DBMS
C2	OS

Student_Course

Student_ID	Course_ID	Marks
S1	C1	80
S1	C2	75
S2	C1	85

Now there is no partial dependency.

3NF — Third Normal Form

A table is in 3NF if:

1. It is already in 2NF, and
2. It has no transitive dependency.

Transitive Dependency

When:

A → B and B → C

therefore:

A → C

where B is not a candidate key.

Example

Student

Student_ID	Student_Name	Dept_ID	Dept_Name
S1	Rahim	D1	CSE
S2	Karim	D2	EEE
S3	Hasan	D1	CSE

Primary Key = Student_ID

Functional dependencies:

- Student_ID → Student_Name, Dept_ID
- Dept_ID → Dept_Name

Therefore:

Student_ID → Dept_ID → Dept_Name

Dept_Name depends on Student_ID indirectly through Dept_ID.

This is a transitive dependency, so the table is not in 3NF.

Convert to 3NF

Student

Student_ID	Student_Name	Dept_ID
S1	Rahim	D1
S2	Karim	D2
S3	Hasan	D1

Department

Dept_ID	Dept_Name
D1	CSE
D2	EEE

Now the transitive dependency is removed.

1NF → 2NF → 3NF → BCNF

Normal Form	Main condition
1NF	Atomic values; no repeating groups
2NF	1NF + no partial dependency

3NF	2NF + no transitive dependency
BCNF	Every determinant must be a superkey

remember

2NF → Remove partial dependency

3NF → Remove transitive dependency

BCNF → Every determinant must be a superkey

BCNF — Boyce-Codd Normal Form

BCNF is a stronger version of **3NF (Third Normal Form)** used in database normalization to reduce redundancy and prevent update anomalies.

A relation (table) is in **BCNF** if:

1. **For every non-trivial functional dependency X→Y , X must be a superkey.**

In simple words:

2. **Every determinant must be a candidate key (or a superkey).**

Consider:

Student_Course

Student	Course	Instructor
S1	DBMS	I1
S2	DBMS	I1
S3	OS	I2

Suppose we have these functional dependencies:

1. **(Student, Course) → Instructor**
2. **Instructor → Course**

Here:

- (Student, Course) is a candidate key.
- But **Instructor → Course** exists.
- Instructor is **not a superkey**.

Therefore, the table **violates BCNF**.

Decomposition

We can decompose it into:

Instructor_Course

Instructor	Course
I1	DBMS
I2	OS

and

Student_Instructor

Student	Instructor
S1	I1
S2	I1
S3	I2

Now the determinants are keys in their respective relations, so the relations satisfy **BCNF**.

Key difference: 3NF vs BCNF

3NF	BCNF
Less strict	More strict
Allows some dependencies where determinant isn't a superkey	Every determinant must be a superkey
A relation can be in 3NF but not BCNF	BCNF always satisfies 3NF

Easy rule to remember:

BCNF = For every FD, the left side must be a superkey.

Dependencies (important)

1. Functional Dependency (FD)

A **functional dependency** exists when one attribute uniquely determines another attribute.

Notation: A --> B means "A determines B."

Example: StudentID → StudentName

A StudentID uniquely identifies one student.

2. Partial Dependency : A **partial dependency** occurs when a non-key attribute depends only on part of a composite primary key instead of the entire key.

Example:

Primary Key: (StudentID, CourseID)

Suppose StudentID → StudentName

StudentName depends only on StudentID, not on the whole key.
This violates **2NF**.

1. **Transitive Dependency:** A **transitive dependency** occurs when a non-key attribute depends on another non-key attribute instead of directly depending on the primary key.

Example:

StudentID → DeptID
DeptID → DeptName
Therefore, StudentID → DeptName
This violates **3NF**.

Normalization is a systematic process of organizing relational databases to reduce redundancy and improve data consistency. **1NF** removes repeating groups, **2NF** removes partial dependency, **3NF** removes transitive dependency, and **BCNF** further strengthens database design by ensuring that every determinant is a candidate key.

04	Explain different types of keys in DBMS with examples (Primary, Candidate, Super, Foreign, Composite). What are the disadvantages of indexing in database systems?

A **key** in a **Database Management System (DBMS)** is one or more attributes used to uniquely identify a record in a table and establish relationships between tables. Keys help maintain **data integrity**, prevent duplicate records, and support efficient data retrieval.

Types of Keys in DBMS

1. Primary Key

A **Primary Key** is a key that uniquely identifies each record in a table. It **cannot contain NULL values** and **must be unique**.

Student

StudentID	Name	Department
101	Rahim	CSE
102	Karim	EEE

Here,

Primary Key = StudentID

Characteristics of Primary Key

- Unique, which identify the rows of the table uniquely.
- Cannot be NULL
- Only one primary key per table
- Automatically creates uniqueness

2. Candidate Key

A **Candidate Key** is any attribute or set of attributes that can uniquely identify a record.

Among all candidate keys, one is selected as the **Primary Key**, while the remaining are called **Alternate Keys**.

StudentID	NationalID	Email
101	34567890	rahim@gmail.com

Possible Candidate Keys:

- StudentID
- NationalID
- Email

Suppose StudentID is chosen as the Primary Key.

Then,

- Candidate Keys = StudentID, NationalID, Email
- Primary Key = StudentID
- Alternate Keys = NationalID, Email

3. Super Key

A **Super Key** is any combination of attributes that uniquely identifies a record.

It may contain extra attributes that are not necessary for uniqueness.

StudentID	Name	Phone

Possible Super Keys:

- ✓ StudentID
- ✓ StudentID + Name

- ✓ StudentID + Phone
- ✓ StudentID + Name + Phone
- ✓ All uniquely identify a record.

4. Foreign Key

A **Foreign Key** is an attribute in one table that refers to the **Primary Key** of another table.
It establishes a relationship between tables and enforces **referential integrity**.

Department

DeptID	DeptName
10	CSE
20	EEE

Student

StudentID	Name	DeptID
101	Rahim	10
102	Karim	20

Here,

Student.DeptID

is the **Foreign Key**.

5. Composite Key

A **Composite Key** is a key that consists of **two or more attributes (columns) together** to uniquely identify a record in a table.
A composite key is a combination of two or more attributes that collectively uniquely identify each tuple/row of a relation.
Consider a Student_Course table:

Student_ID	Course_ID	Student_Name	Course_Name
S01	C01	Rahim	DBMS
S01	C02	Rahim	OS
S02	C01	Karim	DBMS
S02	C02	Karim	OS

Here, neither Student_ID nor Course_ID alone can uniquely identify a row.

The Internet can grow to accommodate billions of connected devices without requiring dedicated circuits.

6. Cost Effective

Resources are allocated only when data is being transmitted, reducing infrastructure costs compared to dedicated circuits.

7. Supports Different Types of Traffic

Suitable for:

- Web browsing.
- Email.
- Video streaming.
- File transfer.
- Cloud services.
- Voice over IP (VoIP).

Packet Switching vs Circuit Switching

Feature	Packet Switching	Circuit Switching
Connection	No dedicated path	Dedicated path required
Bandwidth	Shared	Reserved
Efficiency	High	Lower when idle
Reliability	High	Lower if circuit fails
Cost	Lower	Higher
Internet Usage	Yes	No (traditional telephone systems)

Packet switching is more suitable for Internet communication because it efficiently shares bandwidth, supports millions of users simultaneously, provides dynamic routing around failures, and offers better scalability and cost efficiency than circuit switching. These characteristics make it the foundation of modern Internet communication.

16

A 2 GB File is Transferred Over a 500 Mbps Network

Given

- **File Size = 2 GB**

- Bandwidth = 500 Mbps
- Queuing Delay = 15 ms
- Processing Delay = 5 ms
- Distance = 1000 km
- Propagation Speed = 2×10^8 m/s

Calculate:

a) Transmission Delay
b) Propagation Delay
c) Total Transmission Time
d) Round Trip Time (RTT)

Step 1: Convert Units

Using networking convention:

2 GB = 2×10^9 Bytes

Convert to bits:

$2 \times 10^9 \times 8 = 16 \times 10^9$ bits

Bandwidth:

500 Mbps = 500×10^6 bits/s

Transmission Delay

Formula:

$$\text{Transmission Delay} = \frac{\text{File Size (bits)}}{\text{Bandwidth}}$$

$$= \frac{16 \times 10^9}{500 \times 10^6} = 32 \text{ s}$$

Transmission Delay = 32 seconds

2. Propagation Delay

Distance:

1000 km = 1,000,000 m

Formula:

$$\text{Propagation Delay} = \frac{\text{Distance}}{\text{Propagation Speed}}$$

$$= \frac{1{,}000{,}000}{2 \times 10^8} = 0.005 \text{ s} = 5 \text{ ms}$$

Propagation Delay = 5 ms

3. Total Transmission Time

   Formula:

$$\text{Total Time} = \text{Transmission Delay} + \text{Propagation Delay} + \text{Processing Delay} + \text{Queuing Delay}$$

   Convert milliseconds to seconds:

   Propagation Delay = 0.005 s

   Processing Delay = 0.005 s

   Queuing Delay = 0.015 s

$$32 + 0.005 + 0.005 + 0.015 = 32.025 \text{ s}$$

   Total Transmission Time = 32.025 seconds

4. Round Trip Time (RTT)

   RTT measures the time for a packet to travel from sender to receiver and back.

   Formula:

$$\boldsymbol{RTT} = \mathbf{2} \times (\textbf{Propagation Delay}) + \textbf{Processing Delay} + \textbf{Queuing Delay}$$

$$= 2 \times 5 + 5 + 15 = 30 \text{ ms}$$

$$\text{RTT} = 30 \text{ ms}$$

Note: RTT is typically calculated using propagation delay in both directions plus any specified processing and queuing delays. It does not include the 32-second transmission delay of the entire 2 GB file.

Parameter	Formula	Result
Transmission Delay	File Size / Bandwidth	32 s
Propagation Delay	Distance / Propagation Speed	5 ms
Processing Delay	Given	5 ms
Queuing Delay	Given	15 ms
Total Transmission Time	Transmission + Propagation + Processing + Queuing	32.025 s
Round Trip Time (RTT)	2 × Propagation + Processing + Queuing	30 ms

The transmission of a 2 GB file over a 500 Mbps network requires 32 seconds for data transmission. The propagation delay is 5 ms, and including the given processing and queuing delays, the total transmission time becomes 32.025 seconds. The Round Trip Time (RTT) is 30 ms, representing the time for a signal to travel to the destination and back, including the specified processing and queuing delays.

17

What is Handshaking in Computer Networks? Why is it Required? Explain Three-Way Handshake.

Handshaking is a communication process in computer networks where two devices exchange control messages to establish, maintain, or terminate a connection before transferring data.
It ensures that both sender and receiver are ready and synchronized.

Why Handshaking is Required?

Handshaking is required for:

1. Establishing Connection

   It confirms that both devices are available before communication starts.

2. Synchronization

   It synchronizes sequence numbers and communication parameters.

3. Reliability

   It ensures data is transmitted between active and ready devices.

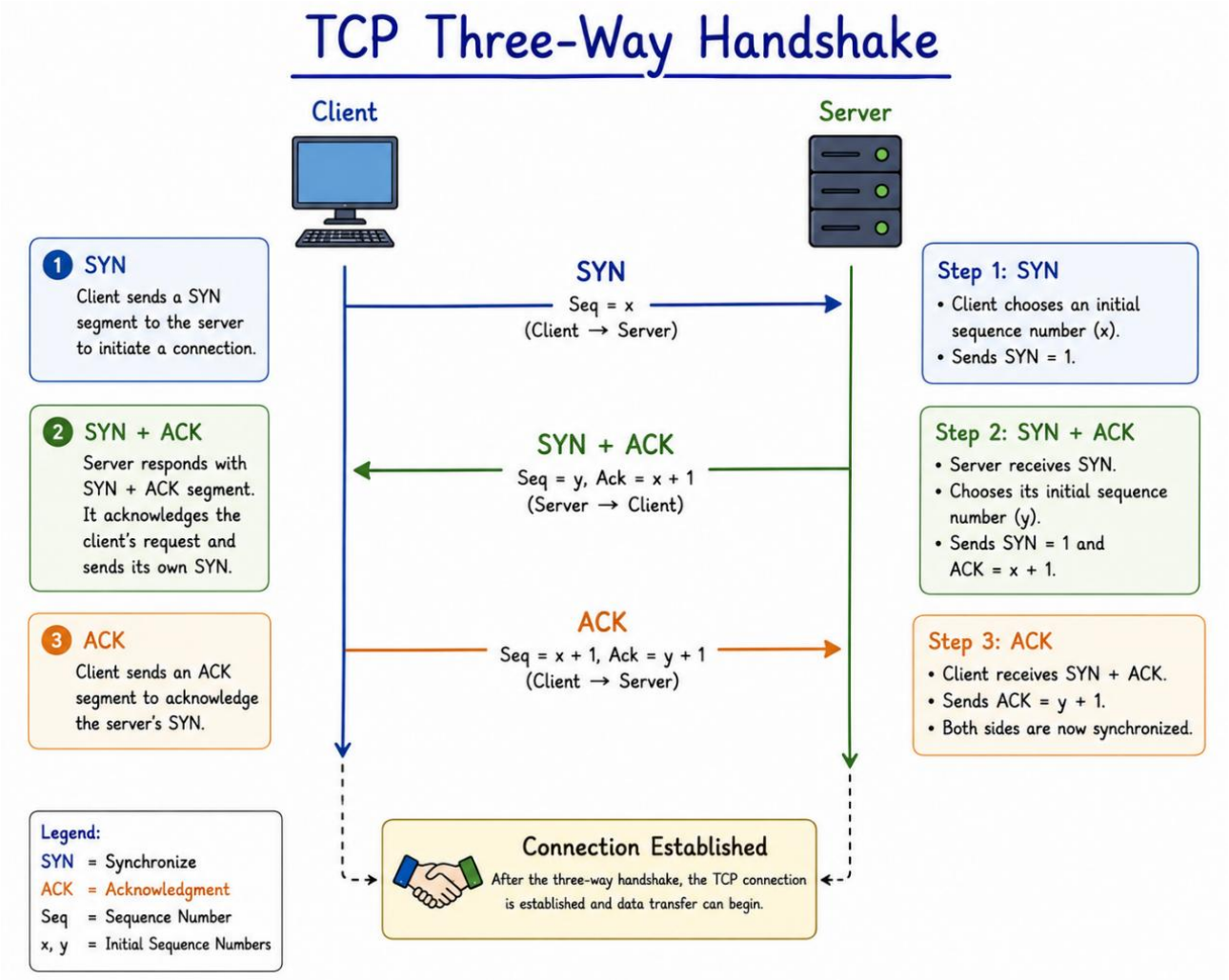
4. Error Control

   It helps detect connection problems before data transmission.

TCP Three-Way Handshake

TCP uses a **three-way handshake** to establish a reliable connection between client and server.
The three steps are:

1. **SYN**
2. **SYN + ACK**
3. **ACK**



Step Explanation

Step 1: SYN

Client sends a SYN (Synchronize) packet.

Purpose:

- Request connection.
- Send initial sequence number.

Example:

Client → Server

SYN = 100

Step 2: SYN + ACK

Server replies with:

- SYN → Server's sequence number.
- ACK → Acknowledges client's request.

Example:

Server → Client

SYN = 500

ACK = 101

Step 3: ACK

Client sends acknowledgment.

Connection is established.

Example:

Client → Server

ACK = 501

Flow Control vs Congestion Control

Feature	Flow Control	Congestion Control
Definition	Controls data flow between sender and receiver	Controls traffic load in the network
Problem Solved	Receiver overload	Network overload
Controlled By	Receiver	Network condition
Purpose	Prevent receiver buffer overflow	Prevent packet loss
Example	TCP Sliding Window	TCP Congestion Window

TCP Congestion Control

TCP controls congestion using four mechanisms:

1. Slow Start

- Starts with a small congestion window.
- Increases gradually.

2. Congestion Avoidance

- Growth becomes slower after reaching threshold.

3. Fast Retransmit

- Quickly retransmits lost packets after duplicate ACKs.

4. Fast Recovery

- Reduces sending rate but avoids restarting completely.

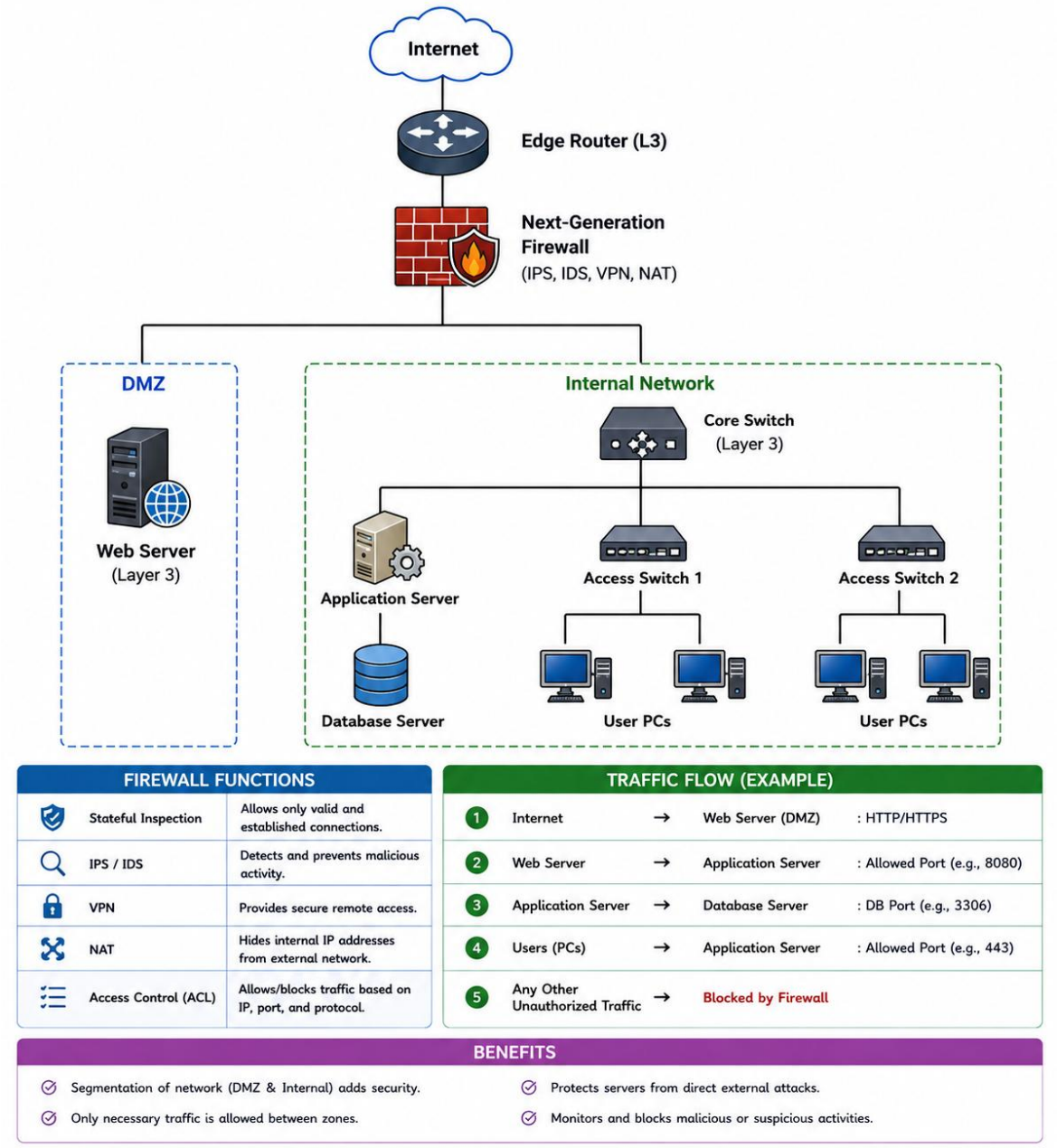
Handshaking establishes reliable communication between devices. TCP uses the **three-way handshake (SYN, SYN+ACK, ACK)** to create a connection. Flow control manages receiver capacity, while congestion control manages network traffic conditions.

18

Design an Enterprise Network for a Commercial Bank Using the OSI Model.

An Enterprise Network is a large-scale communication infrastructure designed to connect users, servers, applications, and network devices securely and efficiently. In a commercial bank, the enterprise network must provide high availability, confidentiality, integrity, authentication, fault tolerance, and scalability because it handles sensitive financial transactions, customer information, and mission-critical banking applications. The OSI (Open Systems Interconnection) Model, developed by the International Organization for Standardization (ISO), divides network communication into seven logical layers. Each layer performs a specific function and interacts only with its adjacent layers, making network design modular, easier to troubleshoot, secure, and interoperable.

Enterprise Network Diagram



Network Components

Component	Function
Internet	External network where customers access online banking services.
Edge Router	Connects the bank's network to the Internet and performs routing between external and internal networks.

Firewall	Filters incoming and outgoing traffic based on security policies and prevents unauthorized access.
DMZ (Demilitarized Zone)	Isolated network segment hosting publicly accessible services such as the Web Server.
Web Server	Handles HTTP/HTTPS requests from customers and provides the online banking interface.
Application Server	Executes banking business logic, authentication, transaction processing, and API services.
Database Server	Stores customer accounts, transaction records, and banking data securely.
Core Switch	High-speed Layer 3 switch connecting servers, access switches, and network segments.
Access Switch	Connects end-user devices to the enterprise network.
User PCs	Used by bank employees to access banking applications and internal services.

Data Flow Through the OSI Layers

When a customer accesses the bank's online banking system, data travels through all seven layers of the OSI Model.

OSI Layer	Data Flow in the Bank Network
Layer 7 – Application	The customer opens a web browser and sends an HTTPS request to the bank's website. The Web Server processes the request and forwards it to the Application Server.
Layer 6 – Presentation	Data is encrypted using SSL/TLS, compressed if necessary, and converted into a standard format before transmission.
Layer 5 – Session	A secure communication session is established between the client and the Web Server. Authentication and session management occur here.
Layer 4 – Transport	TCP establishes a reliable connection, performs segmentation, sequencing, acknowledgments, and error recovery. HTTPS uses TCP Port 443.
Layer 3 – Network	IP packets are routed by the Edge Router and Core Switch toward the destination server using IPv4/IPv6 addressing.

Layer 2 – Data Link	Ethernet frames are created, MAC addresses are added, VLAN tagging is applied, and switches forward frames to the correct destination.
Layer 1 – Physical	Electrical signals or optical pulses travel through copper cables, fiber-optic cables, or wireless media between devices.

Security Measures at Each OSI Layer

OSI Layer	Security Measures
Layer 7 – Application	User authentication, Multi-Factor Authentication (MFA), Web Application Firewall (WAF), API security, input validation, secure coding practices.
Layer 6 – Presentation	SSL/TLS encryption, digital certificates, AES encryption, data compression.
Layer 5 – Session	Secure session establishment, session timeout, session tokens, re-authentication, VPN tunnels.
Layer 4 – Transport	TCP filtering, stateful firewall inspection, port security, SYN flood protection, Transport Layer Security (TLS).
Layer 3 – Network	IP filtering, Access Control Lists (ACLs), routing security, IPSec VPN, anti-spoofing, intrusion prevention.
Layer 2 – Data Link	VLAN segmentation, MAC filtering, IEEE 802.1X authentication, Dynamic ARP Inspection (DAI), DHCP Snooping, Port Security.
Layer 1 – Physical	CCTV surveillance, biometric access control, locked server rooms, redundant power supply, UPS, physical cable protection.

Advantages of Using the OSI Model in Enterprise Network Design

Advantage	Explanation
Modular Design	Each layer performs a specific function, making the network easier to design and maintain.
Easy Troubleshooting	Problems can be isolated to a specific OSI layer, reducing troubleshooting time.
Improved Security	Security mechanisms can be implemented independently at multiple layers, providing defense in depth.
Interoperability	Devices from different vendors can communicate using standardized protocols.

Scalability	New devices, servers, and applications can be added without redesigning the entire network.
Simplified Maintenance	Changes made at one layer generally do not affect other layers.
Better Performance	Each layer optimizes specific networking tasks, improving overall efficiency.
Supports Layered Security	Firewalls, IDS/IPS, encryption, VLANs, ACLs, and authentication can work together across different layers.
Technology Independence	Hardware or protocol changes at one layer do not require modifications to other layers.

The OSI Model provides a structured framework for designing secure, scalable, and manageable enterprise networks. In a commercial bank, Internet traffic first reaches the Edge Router, passes through a **Next-Generation Firewall**, and then enters the DMZ, where the Web Server receives customer requests. The Web Server forwards validated requests to the Application Server, which processes banking operations and retrieves or updates information on the Database Server. Internal communication is managed by the Core Switch and Access Switches, which connect employee User PCs and other network devices. By implementing security controls such as firewalls, **VLANs, ACLs, SSL/TLS** encryption, IPS/IDS, VPNs, authentication mechanisms, and physical security, each OSI layer contributes to protecting sensitive banking information. Using the OSI Model also improves interoperability, simplifies troubleshooting, enhances security, and ensures that the enterprise network remains reliable, scalable, and efficient for modern banking operations.

Read :

Edge Router, **Next-Generation Firewall, VLANs, ACLs, SSL/TLS** encryption, IPS/IDS, VPNs,

19

Describe Classful ip address

IPv4 IP Classes – Complete Description

An IPv4 address is a 32-bit address used to identify a device/interface on a network. It is written as four 8-bit octets, for example 192.168.1.10. Traditionally, IPv4 addresses were

divided into five classes: Class A, B, C, D, and E. Class A, B, and C were used for unicast networking, Class D for multicast, and Class E was reserved for experimental purposes.

1. Class A

Range: 1.0.0.0 – 126.255.255.255

First octet: 1–126

Default subnet mask: 255.0.0.0

CIDR: /8

Structure:

Network | Host | Host | Host

Class A uses 8 bits for the network portion and 24 bits for the host portion.

Number of possible addresses per Class A network:

2^24 = 16,777,216

Traditionally, usable hosts per network are:

2^24 - 2 = 16,777,214

The -2 is because one address is the network address and one is the broadcast address.

Example:

10.20.30.40/8

Network address: 10.0.0.0

Host portion: 20.30.40

A major private Class A range is: 10.0.0.0/8

Private range: 10.0.0.0 – 10.255.255.255

2. Class B

Range: 128.0.0.0 – 191.255.255.255

First octet: 128–191

Default subnet mask: 255.255.0.0

CIDR: /16

Structure:

Network | Network | Host | Host

Class B uses 16 bits for the network portion and 16 bits for the host portion.

Number of addresses per Class B network:

2^16 = 65,536

Traditionally, usable hosts per network:

2^16 - 2 = 65,534

Example:

172.20.10.50/16

Network address: 172.20.0.0

Host portion: 10.50

The private Class B range is: 172.16.0.0/12

Private range: 172.16.0.0 – 172.31.255.255

Important: Not every 172.x.x.x address is private. Only 172.16.0.0 – 172.31.255.255 is part of the private range.

3. Class C

Range: 192.0.0.0 – 223.255.255.255

First octet: 192–223

Default subnet mask: 255.255.255.0

CIDR: /24

Structure:

Network | Network | Network | Host

Class C uses 24 bits for the network portion and 8 bits for the host portion.

Number of addresses per Class C network:

2^8 = 256

Traditionally, usable hosts per network:

2^8 - 2 = 254

Example: 192.168.1.50/24

Network address: 192.168.1.0

Host portion: 50

The private Class C range is: 192.168.0.0/16

Private range: 192.168.0.0 – 192.168.255.255

Examples of private Class C addresses:

192.168.1.1

192.168.1.50

192.168.100.20

4. Class D

Range: 224.0.0.0 – 239.255.255.255

Purpose: Multicast

Class D is not used for normal host/network addressing.

Multicast allows one sender to send traffic to a group of receivers.

Example:

224.0.0.1

This is a well-known multicast address representing all hosts on the local subnet.

Class D does not use the traditional network/host division used by Classes A, B, and C.

5. Class E

Range: 240.0.0.0 – 255.255.255.255

Purpose: Experimental/reserved

Class E addresses were reserved for experimental or future use and are not used as normal unicast host addresses.

255.255.255.255 is the IPv4 limited broadcast address.

How to Identify the Class

Look at the first octet:

1–126 → Class A

128–191 → Class B

192–223 → Class C

224–239 → Class D

240–255 → Class E

Note: 127.0.0.0/8 is reserved for loopback, so it is not used as a normal Class A network. 0.0.0.0/8 also has special purposes.

Why These Class Ranges Exist

Class	begins with	first-octet range	Private IP Range
A	0xxxxxxx	1–126	10.0.0.0 – 10.255.255.255
B	10xxxxxx	128–191	172.16.0.0 – 172.31.255.255

C	110xxxxx	192–223	192.168.0.0 – 192.168.255.255
D	1110xxxx	224–239	
E	1111xxxx	240–255	

Private IPv4 addresses are used inside private networks such as home, office, and enterprise networks. They are not directly routable across the public Internet.

Remember that **IP class and private/public status are different concepts**. For example, 10.1.1.1 is a private address that falls within the traditional Class A range, while 8.8.8.8 is a public address that also falls within the traditional Class A range.

Classful Addressing vs CIDR

Classful addressing is an older IPv4 addressing system.

Traditional defaults were:

Class A → /8

Class B → /16

Class C → /24

Modern networks primarily use **CIDR (Classless Inter-Domain Routing)** and subnet masks rather than relying on Class A/B/C boundaries.

For example:

192.168.1.0/26

A /26 means 26 bits are used for the network portion:

32 - 26 = 6 host bits

Total addresses:

2^6 = 64

Traditionally usable host addresses:

64 - 2 = 62

So 192.168.1.0/26 provides 62 traditionally usable host addresses.

This is why understanding subnetting and CIDR is more important for modern networking than simply memorizing Class A, B, and C.

Quick Revision Table

Class	First Octet	Address Range	Default Mask	CIDR	Traditional Usable Hosts
A	1–126	1.0.0.0 – 126.255.255.255	255.0.0.0	/8	16,777,214
B	128–191	128.0.0.0 – 191.255.255.255	255.255.0.0	/16	65,534
C	192–223	192.0.0.0 – 223.255.255.255	255.255.255.0	/24	254
D	224–239	224.0.0.0 – 239.255.255.255	N/A	N/A	Multicast
E	240–255	240.0.0.0 – 255.255.255.255	N/A	N/A	Experimental/Reserved

20

a) DDGF Consider a data frame: **1101011011**; using CRC with generator polynomial, $CX = x^3 + x + 1$, calculate the remainder (CRC bits) showing all division steps. (07)

b) A message, $M = 1011101$ is to be transmitted with parity-based error detection. (08)

i. Calculate the parity bits considering even parity.

ii. Explain how this technique can detect single bit errors but may fail to detect two-bit errors.

(a) CRC Calculation **7**

Given data frame:

$$D = 1101011011$$

Generator polynomial:

$$G(x) = x^3 + x + 1$$

The binary representation of the generator polynomial is obtained from the coefficients of $x^3, x^2, x, 1$:

$$x^3 + 0x^2 + x + 1$$

Therefore:

$$\boxed{G = 1011}$$

Since the degree of the generator is 3, append **3 zeros** to the data:

$$1101011011 \rightarrow 1101011011000$$

Now perform modulo-2 division using XOR.

Component	Primary Responsibility	Key Role
HDFS	Distributed Data Storage	Stores data blocks reliably across nodes
YARN	Resource Management & Scheduling	Allocates CPU, memory, and coordinates jobs
MapReduce	Distributed Data Processing	Resource Management & Scheduling
Hadoop Common	Shared Utilities & Libraries	Provides underlying infrastructure & APIs

Memory Rule: HDFS = Store | YARN = Manage | MapReduce = Process | Common = Support

Question 3: A 1 GB file is stored in HDFS with a block size of 128 MB. Ignoring metadata, how many HDFS blocks are required?

a) 4
b) 8
c) 16
d) 128

Correct- B) 8

Detailed Explanation:

$$\text{Total Blocks} = \frac{\text{File Size}}{\text{Block Size}}$$

- File Size = 1 GB = 1024 MB (binary standard)
- Block Size = 128 MB
- Number of Blocks = $\frac{1024\ \text{MB}}{128\ \text{MB}} = 8$ blocks

(Note: In decimal standard where 1 GB = 1000 MB, $\frac{1000}{128} = 7.81$*, which still rounds up to* ***8 blocks*** *because HDFS allocates a full block structure for any remaining fractional data.)*

Question 4: An HDFS file consists of 10 blocks and has a replication factor of 3. Assuming all replicas are successfully stored, how many block replicas exist across the cluster?

A) 10
B) 13
C) 20
D) 30

ANS- D) 30

Detailed Explanation:

$$Total\ Block\ Replicas = Unique\ Blocks \times Replication\ Factor$$

- Number of Unique File Blocks = 10 blocks
- Replication Factor = 3 (1 original block + 2 duplicate replicas)
- Total Replicas across Cluster = $10 \times 3 = 30$ block replicas

This guarantees that even if up to 2 DataNodes containing a specific block fail simultaneously, the data remains accessible from the 3rd DataNode replica.

05

A* (A-Star) Algorithm — বাংলায়

A* বা A-Star Algorithm হলো একটি informed search algorithm, যা কোনো graph বা map-এর মধ্যে একটি starting node থেকে goal/destination node পর্যন্ত সবচেয়ে কম cost-এর পথ (shortest/least-cost path) খুঁজে বের করতে ব্যবহৃত হয়। এটি Artificial Intelligence (AI), GPS/navigation system, robotics, computer games এবং বিভিন্ন path-finding সমস্যায় ব্যাপকভাবে ব্যবহৃত হয়।

A* Algorithm-এর মূল ধারণা হলো—একটি node পর্যন্ত আসতে ইতোমধ্যে কত cost হয়েছে এবং সেই node থেকে goal পর্যন্ত যেতে আনুমানিক কত cost লাগতে পারে—এই দুইটি বিষয় একসঙ্গে বিবেচনা করা। এজন্য A* প্রতিটি node-এর জন্য নিচের formula ব্যবহার করে:

$$f(n) = g(n) + h(n)$$

এখানে, $g(n)$ হলো starting node থেকে বর্তমান node n পর্যন্ত আসতে যে actual cost হয়েছে। $h(n)$ হলো বর্তমান node n থেকে goal node পর্যন্ত যাওয়ার estimated cost, যাকে heuristic value বলা হয়। আর $f(n)$ হলো starting node থেকে goal পর্যন্ত যাওয়ার সম্ভাব্য মোট cost-এর একটি estimate। A* সাধারণত যে node-এর $f(n)$ value সবচেয়ে কম, সেটিকে পরবর্তী node হিসেবে নির্বাচন করে।

উদাহরণ (Example)

ধরা যাক, Start থেকে আমরা C node-এ পৌঁছেছি। C পর্যন্ত আসতে actual cost হয়েছে:

$$g(\mathrm{C}) = 6$$

এবং C থেকে Goal পর্যন্ত আনুমানিক cost:

$$h(\mathrm{C}) = 4$$

তাহলে,

$$f(\mathrm{C}) = g(\mathrm{C}) + h(\mathrm{C}) = 6 + 4 = 10$$

অন্যদিকে D node-এর জন্য যদি $g(\mathrm{D}) = 5$ ও $h(\mathrm{D}) = 7$ হয়, তবে $f(\mathrm{D}) = 5 + 7 = 12$।

এক্ষেত্রে A* C node নির্বাচন করবে, কারণ C-এর $f(\mathrm{C}) = 10$, যা D-এর $f(\mathrm{D}) = 12$-এর চেয়ে কম।

Heuristic Function

A* Algorithm-এর গুরুত্বপূর্ণ অংশ হলো heuristic function $h(n)$। এটি বর্তমান node থেকে goal node পর্যন্ত যাওয়ার সম্ভাব্য cost অনুমান করে। বিভিন্ন সমস্যায় বিভিন্ন heuristic ব্যবহার করা যায়।

- যদি একটি grid-এ শুধু up, down, left এবং right দিকে চলা যায়, তাহলে **Manhattan Distance** ব্যবহার করা যায়:

$$h(n) = |x_n - x_g| + |y_n - y_g|$$

- আর যদি সরাসরি যেকোনো দিকে চলাচল করা যায়, তাহলে **Euclidean Distance** ব্যবহার করা যেতে পারে:

$$h(n) = \sqrt{(x_n - x_g)^2 + (y_n - y_g)^2}$$

একটি ভালো heuristic সাধারণত goal-এর দিকে search-কে দ্রুত পরিচালনা করে। **Admissible heuristic** এমন একটি heuristic যা প্রকৃত minimum cost-এর চেয়ে বেশি অনুমান করে না। এই ধরনের heuristic ব্যবহার করলে উপযুক্ত শর্তে A* optimal বা shortest path খুঁজে পেতে পারে।

A* Algorithm-এর ধাপ (Steps)

1. প্রথমে, starting node-কে **OPEN list**-এ রাখা হয়।
2. দ্বিতীয়ত, starting node-এর $g(n)$, $h(n)$ এবং $f(n)$ হিসাব করা হয়।
3. তৃতীয়ত, OPEN list থেকে সবচেয়ে কম $f(n)$ value-সম্পন্ন node নির্বাচন করা হয়।
4. চতুর্থত, নির্বাচিত node যদি Goal node হয়, তাহলে search শেষ হয় এবং path তৈরি করা হয়।
5. পঞ্চমত, node-টি Goal না হলে তার neighboring বা adjacent node-গুলো পরীক্ষা করা হয়।
6. ষষ্ঠত, প্রতিটি neighbor-এর জন্য $g(n)$, $h(n)$ এবং $f(n)$ হিসাব করা হয়।
7. সপ্তমত, কোনো neighbor-এ যাওয়ার নতুন path আগের path-এর চেয়ে কম cost-এর হলে সেই path update করা হয়।
8. অষ্টমত, বর্তমান node-কে explored/closed set-এ রাখা হয় এবং পরবর্তী সবচেয়ে promising node নির্বাচন করা হয়।

এই প্রক্রিয়া চলতে থাকে যতক্ষণ না Goal node পাওয়া যায় অথবা কোনো valid path অবশিষ্ট না থাকে।

Dijkstra-এর সঙ্গে পার্থক্য

A* Algorithm-এর সঙ্গে Dijkstra's Algorithm-এর অনেক মিল রয়েছে। তবে Dijkstra শুধুমাত্র ইতোমধ্যে হওয়া cost বিবেচনা করে: $f(n) = g(n)$। অন্যদিকে A* actual cost এবং estimated remaining cost দুটিই বিবেচনা

করে: $f(n) = g(n) + h(n)$। তাই A* সাধারণত goal-এর দিকটি বিবেচনা করে search করতে পারে। আবার যদি $h(n) = 0$ হয়, তাহলে $f(n) = g(n)$, অর্থাৎ A* কার্যত Dijkstra's Algorithm-এর মতো আচরণ করে।

সুবিধা ও অসুবিধা

- **সুবিধা:** A* Algorithm-এর প্রধান সুবিধা হলো এটি shortest বা least-cost path খুঁজে বের করতে পারে এবং একটি ভালো heuristic ব্যবহার করলে অনেক unnecessary node search করা থেকে বিরত থাকতে পারে। এটি GPS, map navigation, robotics, AI এবং computer games-এর path-finding-এর জন্য খুব কার্যকর।
- **অসুবিধা:** A* Algorithm-এর বড় সমস্যা হলো memory consumption; অনেক node OPEN এবং CLOSED set-এ সংরক্ষণ করতে হয়। এছাড়া heuristic function ভালো না হলে A* অনেক বেশি node explore করতে পারে এবং তখন এর performance কমে যেতে পারে।

মনে রাখার সহজ উপায়

A*-এর মূল formula:

$$f(n) = g(n) + h(n)$$

- $g(n)$ = যতদূর এসেছি তার actual cost
- $h(n)$ = সামনে Goal পর্যন্ত আনুমানিক cost
- $f(n)$ = মোট সম্ভাব্য cost

অর্থাৎ, $A^* = \text{Actual Cost} + \text{Estimated Co}$

06

What is Machine Learning? Explain Supervised, Unsupervised, and Reinforcement Learning with Appropriate Examples.

Machine Learning (ML) is a branch of Artificial Intelligence (AI) that enables computers to learn patterns from data or experience and make predictions or decisions without being explicitly programmed with every rule.

Machine Learning is mainly categorized into three major types:

1. Supervised Learning
2. Unsupervised Learning
3. Reinforcement Learning

Supervised Learning

Definition: Supervised Learning is a type of machine learning in which a model is trained using labeled data, where each training example contains input features and a corresponding correct output.

The main objective is to learn a mapping between inputs and outputs so that the model can accurately predict the outputs of new, unseen data.

Example: Email Spam Detection

Suppose we have a dataset containing emails labeled as Spam or Not Spam.

Email	Label
Win a free prize	Spam
Meeting at 10 AM	Not Spam
Claim your reward	Spam
Project report attached	Not Spam

The model learns patterns from these labeled examples. When a new email arrives, it predicts whether it is spam.

How Supervised Learning Works:

1. Collect labeled training data.
2. Extract relevant input features.
3. Train a machine learning model using input-output pairs.
4. Compare predictions with actual labels and minimize prediction error.
5. Evaluate the trained model using unseen data.
6. Use the model to predict outputs for new inputs.

1. Labeled Training Data
2. Input features + correct answers
3. Model Training
4. Trained Model
5. Prediction on New Data
6. Spam / Not Spam

Types of Supervised Learning

A. Classification: Predicts a discrete category or class.

Examples: Spam/Not Spam, Pass/Fail, Disease/No Disease.

B. Regression: Predicts a continuous numerical value.

Examples: House price prediction, temperature forecasting, sales prediction.

Common Algorithms:

- Linear Regression
- Logistic Regression
- Decision Tree
- Random Forest
- Support Vector Machine (SVM)
- K-Nearest Neighbors (KNN)
- Artificial Neural Network (ANN)

Advantages: Produces accurate predictions when sufficient high-quality labeled data are available, and its performance can be measured using known targets.

Disadvantages: Requires labeled datasets, which can be expensive and time-consuming to prepare.

Unsupervised Learning

Definition: Unsupervised Learning is a type of machine learning in which a model is trained using unlabeled data, meaning that the dataset contains input features without predefined target outputs. The objective is to discover hidden patterns, structures, similarities, or relationships within the data.

Example: Customer Segmentation

Suppose a shopping company has customer information, including age, income, and purchasing behavior, but no predefined customer categories.

An unsupervised learning algorithm analyzes the data and identifies groups of customers with similar characteristics.

Customer	Monthly Spending (Tk.)	Visits/Month
A	2,000	3
B	2,500	4
C	15,000	20
D	17,000	22
E	2,200	3

A clustering algorithm might identify:

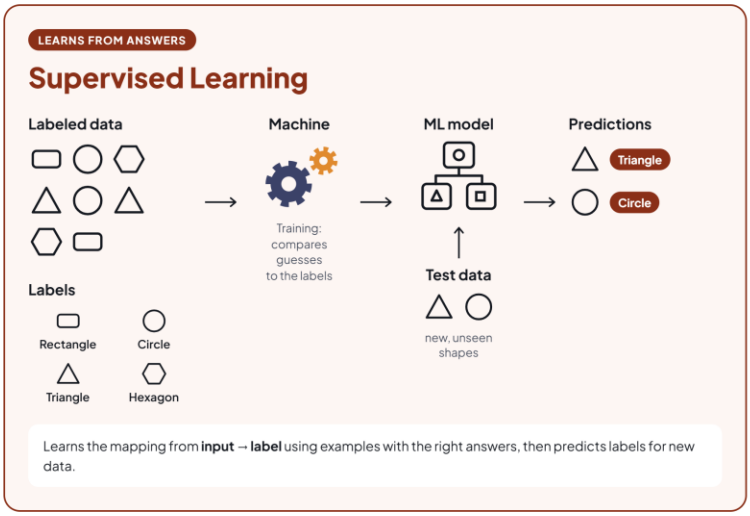
- Cluster 1: Customers A, B, and E — low spending and infrequent visits.
- Cluster 2: Customers C and D — high spending and frequent visits.

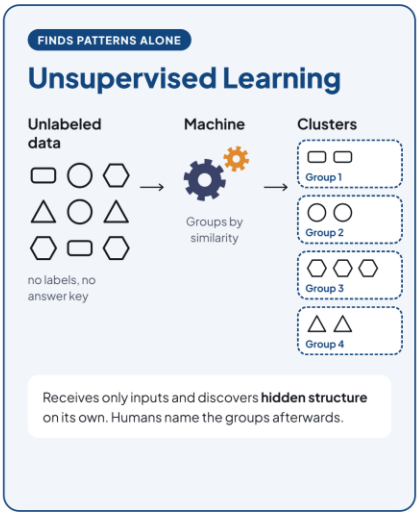
The model discovers these groups without being given predefined labels.

Illustration: Clustering customers into two groups based on their spending and visit frequency.

How Unsupervised Learning Works:

1. Collect unlabeled data.
2. Extract and preprocess relevant features.
3. Apply an unsupervised learning algorithm.
4. Identify hidden structures or relationships.
5. Interpret the resulting clusters, patterns, or representations.





Types of Unsupervised Learning

A. Clustering: Groups similar data points into clusters.

Examples: Customer segmentation, document grouping.

B. Association Rule Learning: Discovers relationships between items.

Example: Customers who purchase bread frequently also purchase butter.

C. Dimensionality Reduction: Reduces the number of features while preserving important information.

Example: Principal Component Analysis (PCA).

Common Algorithms:

- K-Means Clustering
- Hierarchical Clustering
- DBSCAN
- Apriori Algorithm
- Principal Component Analysis (PCA)

Advantages: Does not require labeled datasets and is useful for discovering unknown patterns.

Disadvantages: Results can be difficult to interpret, and evaluating the quality of discovered patterns can be challenging.

Reinforcement Learning (RL)

Definition: Reinforcement Learning is a type of machine learning in which an agent learns to make decisions by interacting with an environment and receiving rewards or penalties based on its actions.

The main objective is to learn a policy that maximizes expected cumulative reward over time.

Unlike supervised learning, reinforcement learning does not require a correct label for every action.

Example: Robot Learning to Navigate a Maze

Suppose a robot must find the shortest path through a maze.

- Moving toward the goal may lead to a positive reward.
- Hitting an obstacle may result in a penalty.
- Reaching the destination produces a large positive reward.

Through repeated interactions, the robot learns a strategy for reaching the destination efficiently.

Main Components of Reinforcement Learning

Component	Description
Agent	The decision-making entity
Environment	The world in which the agent operates
State	Current situation of the environment
Action	A decision made by the agent
Reward	Feedback received after an action
Policy	Strategy for selecting actions
Value Function	Expected future reward from a state or state-action pair

How Reinforcement Learning Works:

1. The agent observes the current state of the environment.
2. The agent selects an action according to its policy.
3. The environment responds to that action.
4. The agent receives a reward and observes the next state.
5. The agent updates its policy or value estimates based on experience.
6. The process repeats to maximize long-term reward.

Example of Rewards in a Maze

Action	Reward

Reach destination	+100
Hit an obstacle	−10
Each movement	−1

These are illustrative reward values. The agent learns which actions produce the best cumulative outcome.

Common Algorithms:

- Q-Learning
- SARSA
- Deep Q-Network (DQN)
- Policy Gradient
- Actor-Critic Methods

Applications: Robotics, game-playing AI, autonomous decision-making, resource allocation, and traffic signal optimization.

Advantages: Learns sequential decision-making strategies through interaction and can adapt to changing environments.

Disadvantages: Training can require many interactions, rewards may be sparse, and poorly designed reward functions can lead to undesirable behavior.

Difference Between Supervised, Unsupervised, and Reinforcement Learning

Feature	Supervised	Unsupervised	Reinforcement
Training data	Labeled	Unlabeled	Interaction experience
Feedback	Correct target	No target labels	Reward signal
Main objective	Predict output	Discover patterns	Maximize reward
Learning method	Input-output mapping	Pattern discovery	Trial and error
Output	Class or value	Clusters or patterns	Policy or actions
Example	Spam detection	Customer clustering	Robot navigation
Algorithm	SVM, Decision Tree	K-Means, PCA	Q-Learning, DQN
Evaluation	Accuracy, MSE	Silhouette score, etc.	Cumulative reward

Practical Example: Banking Sector

Consider a bank using machine learning for different purposes.

Supervised Learning: The bank trains a model using historical loan applications labeled as default or non-default. The model predicts whether a new borrower is likely to default.

Unsupervised Learning: The bank analyzes customer transaction patterns without predefined groups and clusters customers according to their spending and saving behavior.

Reinforcement Learning: A bank may use an RL agent to learn sequential resource-allocation strategies, receiving rewards based on service efficiency and operational constraints.

Thus, the same organization can use all three types of machine learning for different objectives.

07

What is an Artificial Neural Network (ANN)? Explain How ANN Works with an Example.

An Artificial Neural Network (ANN) is a computational model inspired by the structure and functioning of the human brain. It consists of interconnected processing units called artificial neurons, which work together to recognize patterns, process information, learn from data, and make predictions or decisions.

ANN is a fundamental technique of Machine Learning (ML) and is widely used in Deep Learning, image recognition, speech recognition, medical diagnosis, and natural language processing.

Example: An ANN can learn to identify whether an email is spam or not by analyzing thousands of previously labeled emails.

Structure of an Artificial Neural Network

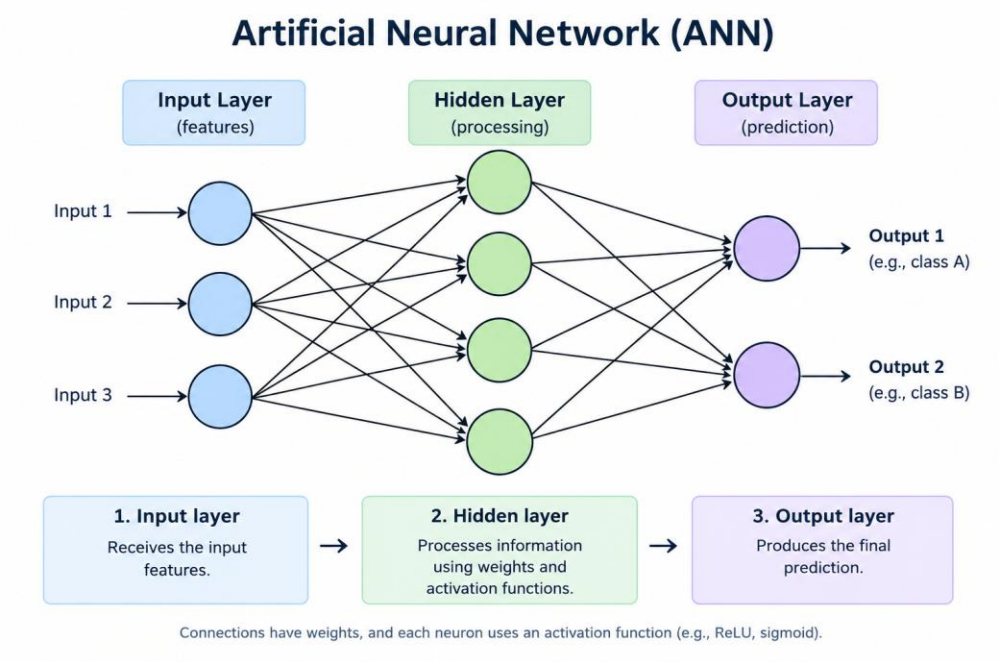
An ANN generally consists of three types of layers:

Figure: Basic architecture of an ANN (4 input neurons, 4 hidden neurons, and 2 output neurons).

a) Input Layer: The first layer receives raw input data, such as numerical values, text features, or image pixels. Each neuron represents an input feature.

b) Hidden Layer: The hidden layer processes input information using weights, biases, and activation functions. An ANN may contain one or multiple hidden layers. Multiple hidden layers allow the network to learn more complex patterns.

c) Output Layer: The final layer produces the prediction or classification result, such as spam/not spam or pass/fail.



How Does an ANN Work?

An ANN works by receiving input data, performing weighted calculations, applying activation functions, generating predictions, and adjusting its parameters to reduce errors.

Step 1: Input Data

The input layer receives information from the dataset.

Example: Suppose an ANN predicts whether a student will pass an examination using two features:

- x_1 = Study hours
- x_2 = Attendance rate

Step 2: Assign Weights and Bias

Each input is multiplied by a weight, which represents the importance of that input. A bias is added to adjust the neuron's output.

The weighted sum is calculated as:

$$z = (w_1 \times x_1) + (w_2 \times x_2) + b$$

Where:

- x_1, x_2 = Input values
- w_1, w_2 = Weights
- b = Bias
- z = Weighted sum

Step 3: Apply Activation Function

The weighted sum passes through an activation function, which introduces non-linearity and helps the network learn complex relationships.

For example, the Sigmoid activation function is:

$$f(z) = 1 / (1 + e^{-z})$$

It converts the input into a value between 0 and 1.

Other common activation functions include ReLU, Tanh, and Softmax.

Step 4: Forward Propagation

Data moves from the input layer through the hidden layers to the output layer. Each neuron performs its calculations and sends its output to the next layer.

This process is called Forward Propagation.

Step 5: Calculate Error (Loss)

The predicted output is compared with the actual target value using a loss function.

For example:

Actual result = 1 (Pass)

Predicted probability = 0.80

The network uses a loss function, such as Binary Cross-Entropy for binary classification, to measure prediction error.

Step 6: Backpropagation

The network calculates how much each weight and bias contributed to the loss using the chain rule of differentiation.

This process is called Backpropagation.

Step 7: Update Weights

An optimization algorithm, such as Gradient Descent, updates the weights to reduce the loss.

New Weight = Old Weight – Learning Rate × Gradient

The learning rate determines how large each update should be.

Step 8: Repeat Training

The ANN repeats forward propagation, loss calculation, backpropagation, and parameter updates over many training iterations until it learns useful patterns.

ANN Training Process

1. Input Data
2. Features enter the network
3. Weighted Sum + Activation

4. Neurons process the inputs
5. Forward Propagation
6. Generate a prediction
7. Calculate Loss
8. Compare prediction with actual result
9. Backpropagation
10. Calculate gradients
11. Update Weights and Biases
12. Optimize parameters
13. Repeat for multiple epochs

Numerical Example of ANN

Suppose a single artificial neuron predicts whether a student will pass based on study hours and attendance.

Given:

- Input x_1 = 0.8 (Normalized study hours)
- Input x_2 = 0.6 (Normalized attendance)
- Weight w_1 = 0.5
- Weight w_2 = 0.4
- Bias b = 0.1

Step 1: Calculate Weighted Sum

$z = (0.8 \times 0.5) + (0.6 \times 0.4) + 0.1$

$z = 0.4 + 0.24 + 0.1$

$z = 0.74$

Step 2: Apply Sigmoid Activation Function

$f(z) = 1 / (1 + e^{-0.74})$

$f(z) \approx 0.677$

Step 3: Generate Prediction

Predicted probability = 67.7%

If the classification threshold is 0.5, the model predicts that the student will Pass.

This is a simplified example of one neuron. A complete ANN combines many neurons across multiple layers.

Common Activation Functions

Activation Function	Formula / Rule	Application
Sigmoid	$1 / (1 + e^{-x})$	Binary classification output
ReLU	$\max(0, x)$	Hidden layers
Tanh	$(e^{x} - e^{-x}) / (e^{x} + e^{-x})$	Hidden layers
Softmax	$e^{xi} / \Sigma e^{xj}$	Multiclass classification output
Linear	$f(x) = x$	Regression output

Advantages of ANN

1. Learning Capability: Learns complex patterns automatically from training data.
2. Nonlinear Processing: Models complicated relationships between inputs and outputs.
3. Generalization: Can make predictions on previously unseen data when properly trained.
4. Parallel Computation: Neural network operations can be accelerated using GPUs.
5. Wide Applications: Useful in image processing, speech recognition, forecasting, and classification.

Disadvantages of ANN

1. Requires large amounts of data for many complex tasks.
2. Training can be computationally expensive.
3. Complex networks are often difficult to interpret.
4. May suffer from overfitting.
5. Performance depends on network architecture, training data, and hyperparameters.

Applications of ANN

Application	Example
Image Recognition	Face detection
Natural Language Processing	Text classification
Healthcare	Disease prediction
Banking	Fraud detection
Cybersecurity	Intrusion detection
Education	Student performance prediction
Business	Sales forecasting

Important Differences: ANN vs Biological Neural Network

ANN	Biological Neural Network
Artificial computational model	Natural nervous system
Contains artificial neurons	Contains biological neurons

Uses numerical weights and biases	Uses biological synapses and signals
Typically trained using optimization algorithms	Learns through biological adaptation
Implemented in software or hardware	Exists in living organisms

08

What are Bias and Variance in Machine Learning? Explain Bias-Variance Tradeoff, Underfitting, and Overfitting with Examples.

Bias in Machine Learning

Bias is the error introduced by overly simplistic assumptions made by a machine learning model. It represents the difference between the average prediction of a model and the actual target value. A model with high bias fails to capture the underlying patterns of the training data, which often results in underfitting.

Example: Suppose we want to predict house prices based on house size. The actual relationship between house size and price is nonlinear, but we use a simple linear regression model.

Because the model assumes a straight-line relationship, it may fail to capture the actual pattern, resulting in high bias.

Characteristics of High Bias:

- Model is too simple.
- Cannot learn complex patterns.
- Usually produces high training and testing errors.
- Often causes underfitting.

How to Reduce Bias:

- Use a more complex model.
- Add relevant features.
- Reduce excessive regularization.
- Train a more expressive model.

Variance in Machine Learning

Definition: Variance measures how much a machine learning model's predictions change when it is trained on different training datasets.

A model with high variance is highly sensitive to small changes in training data and may learn noise instead of general patterns.

Example: Suppose we train a decision tree to predict students' examination results.

A very deep decision tree may perfectly classify all students in the training dataset. However, when new students' data are provided, its predictions may be inaccurate because the model has memorized specific training examples.

Characteristics of High Variance:

- Model is overly complex relative to the available data.
- Highly sensitive to training data.
- Often produces low training error but high testing error.
- Frequently causes overfitting.

How to Reduce Variance:

- Collect more training data.
- Use regularization.
- Reduce model complexity.
- Apply pruning to decision trees.
- Use ensemble methods such as bagging.
- Apply early stopping when appropriate.

3. Bias vs Variance: Visual Explanation

1. High Bias, Low Variance
2. Low Bias, High Variance
3. High Bias, High Variance
4. Low Bias, Low Variance

The red center represents the correct target. Blue dots represent predictions from models trained on different datasets.

Interpretation:

- High Bias, Low Variance: Predictions are consistently far from the correct value.
- Low Bias, High Variance: Predictions vary widely but are centered around the correct value on average.
- High Bias, High Variance: Predictions are both inaccurate on average and inconsistent.
- Low Bias, Low Variance: Predictions are accurate on average and consistent.

What is Underfitting?

Definition: Underfitting occurs when a machine learning model is too simple to learn the underlying patterns of the training data.

It is commonly associated with high bias.

Example: Suppose a dataset follows a quadratic relationship:

$y = x^2$

But we train a linear regression model:

$y = mx + c$

A straight line cannot accurately represent the curved relationship.

Therefore, the model produces high errors on both training and testing datasets.

Causes of Underfitting:

1. Model is too simple.
2. Insufficient or irrelevant features.
3. Excessive regularization.
4. Inadequate training.

Solutions: Increase model complexity, improve feature engineering, reduce excessive regularization, or train longer when insufficient optimization is the problem.

What is Overfitting?

Definition: Overfitting occurs when a machine learning model learns the training data too closely, including noise and irrelevant details, and consequently performs poorly on unseen data.

It is commonly associated with high variance.

Example: Suppose a decision tree is trained to predict whether a customer will purchase a product.

A very deep decision tree may achieve:

- Training accuracy = 99%
- Testing accuracy = 70%

This large performance gap suggests that the model has learned training-specific details rather than general patterns.

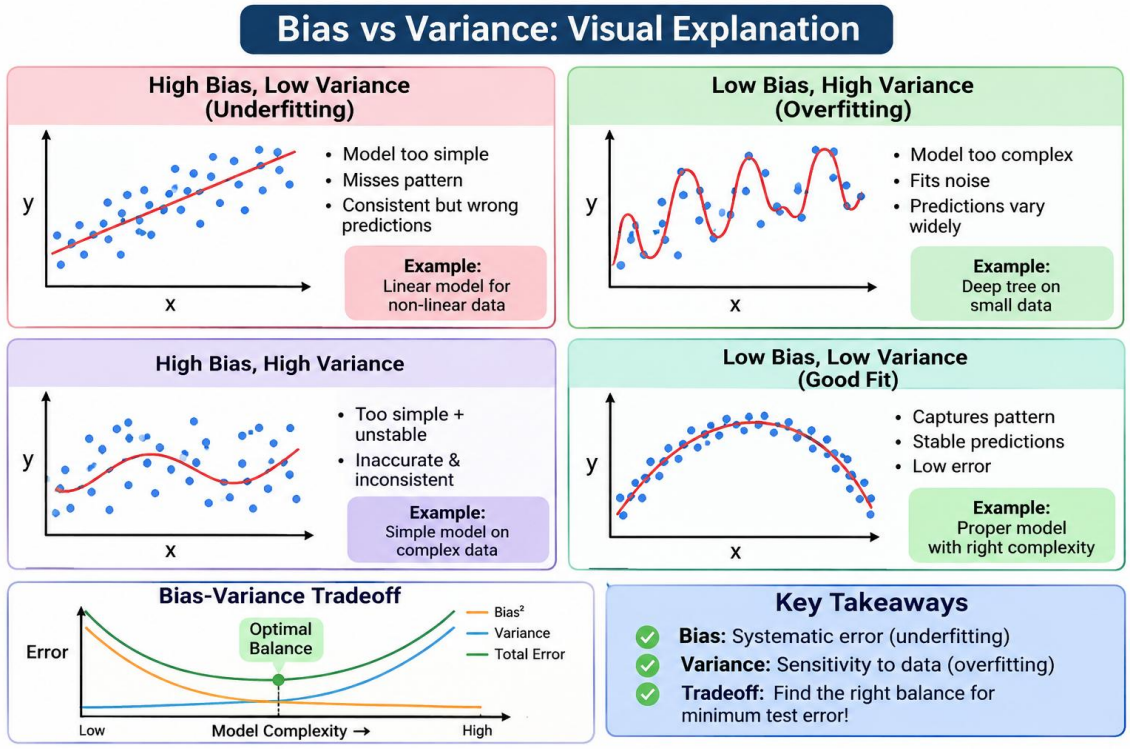
Causes of Overfitting:

1. Excessively complex model.
2. Small training dataset.
3. Noisy training data.
4. Insufficient regularization.
5. Training too long in some neural network settings.

Solutions: Apply regularization, cross-validation, early stopping, data augmentation, pruning, or collect more representative training data.

Graphical Comparison: Underfitting, Good Fit, and Overfitting

Illustrative model fits: too simple, appropriately fitted, and excessively complex.



Bias-Variance Tradeoff

Definition: The Bias-Variance Tradeoff refers to the balance between bias and variance when selecting a machine learning model to achieve good generalization performance.

Generally:

- A model that is too simple has high bias and low variance.
- A model that is too complex may have low bias but high variance.
- A well-balanced model aims to minimize expected prediction error on unseen data.

For squared-error regression, the expected prediction error can be decomposed as:

Expected Test MSE = Bias^2 + Variance + Irreducible Error

Where:

- Bias^2: Error caused by systematic differences between average predictions and the true relationship.
- Variance: Error caused by sensitivity to the training dataset.
- Irreducible Error: Unavoidable noise in the data.

Bias-Variance Tradeoff Curve

Conceptual illustration, not measured data. The minimum of expected test error represents a desirable balance between bias and variance.

Example: Consider polynomial regression models used to predict house prices.

Model	Bias	Variance	Expected Behavior
Degree 1	High	Low	May underfit
Degree 3	Moderate	Moderate	May generalize well
Degree 20	Low	High	May overfit

The exact behavior depends on the dataset, training size, and regularization.

Numerical Example of Bias and Variance

Suppose the actual target value is 100, and we train a model on five different training datasets.

Model A predictions: 80, 82, 78, 81, 79

Mean prediction = (80 + 82 + 78 + 81 + 79) / 5 = 80

Bias = 80 − 100 = −20

$Bias^2 = 400$

Variance = $[(80-80)^2 + (82-80)^2 + (78-80)^2 + (81-80)^2 + (79-80)^2] / 5$

Variance = 10 / 5 = 2

Model B predictions: 80, 120, 90, 110, 100

Mean prediction = 100

Bias = 100 − 100 = 0

$Bias^2 = 0$

Variance = $[(80-100)^2 + (120-100)^2 + (90-100)^2 + (110-100)^2 + (100-100)^2] / 5$

Variance = 1000 / 5 = 200

Metric	Model A	Model B
Actual value	100	100
Mean prediction	80	100
Bias	−20	0
$Bias^2$	400	0
Variance	2	200
$Bias^2$ + Variance	402	200

Interpretation: Model A has high bias but low variance, while Model B has zero bias but high variance. Despite Model B's higher variance, its total expected squared prediction error is lower in this example.

Difference Between Bias and Variance

Basis	Bias	Variance
Meaning	Systematic prediction error	Sensitivity to training data

Main cause	Overly simple assumptions	Excessive sensitivity or complexity
Associated problem	Underfitting	Overfitting
Training error	Usually high	Often low
Testing error	Usually high	Often high
Typical solution	Increase model flexibility	Regularization, more data
Example	Simple linear model for complex data	Deep decision tree on small data

Difference Between Underfitting and Overfitting

Underfitting	Overfitting
Model learns too little from data	Model learns training-specific details
Usually high bias	Usually high variance
High training error	Very low training error
High testing error	High testing error
Model may be too simple	Model may be too complex
Improve features or model capacity	Regularization, pruning, more data

Bias and Variance in ANN

In Artificial Neural Networks, bias and variance are important for selecting network architecture and training strategies.

High Bias in ANN: A neural network with insufficient capacity may fail to learn complex relationships. For example, a very small neural network may be unable to classify complicated image patterns.

High Variance in ANN: A large neural network trained on a small dataset may memorize training examples and perform poorly on new images.

Techniques to Control Bias and Variance in ANN:

- Dropout: Randomly disables selected neurons during training to help reduce overfitting.
- L1/L2 Regularization: Penalizes large or unnecessary weights.
- Early Stopping: Stops training when validation performance stops improving.
- Data Augmentation: Creates additional training variations to improve generalization.
- Cross-Validation: Helps estimate model performance and select suitable hyperparameters.

Important: The bias in the bias-variance tradeoff is different from the bias parameter (b) of an artificial neuron. The former describes systematic prediction error, while the latter is a trainable parameter added to a neuron's weighted input.

09

What is a Genetic Algorithm (GA)? Explain How Genetic Algorithm Works with an Appropriate Example.

A Genetic Algorithm (GA) is a population-based search and optimization algorithm inspired by the principles of natural selection and biological evolution. It is a type of Evolutionary Algorithm (EA) that uses selection, crossover, and mutation to find near-optimal or optimal solutions to complex problems.

Genetic Algorithms were popularized by **John Holland in the 1970s,** particularly through his 1975 book Adaptation in Natural and Artificial Systems.

Example: A Genetic Algorithm can be used to find the shortest delivery route, optimize employee schedules, select important features in machine learning, or solve mathematical optimization problems.

Main Idea: A GA starts with a population of possible solutions, evaluates their quality using a fitness function, and repeatedly generates improved solutions through evolutionary operations.

Important Terminologies of Genetic Algorithm

Term	Description
Gene	A single element of a solution
Chromosome	An encoded representation of a complete candidate solution
Population	A collection of candidate solutions
Fitness Function	Measures the quality of a solution
Selection	Chooses individuals for reproduction
Crossover	Combines genetic information from parents
Mutation	Randomly changes one or more genes
Generation	One iteration of the evolutionary process
Elitism	Preserves the best individuals for the next generation
Termination	Condition for stopping the algorithm