GATE CS Notes according to GATE 2020 syllabus

This page contains GATE CS Preparation Notes / Tutorials on Mathematics, Digital Logic, Computer Organization and Architecture, Programming and Data Structures, Algorithms, Theory of Computation, Compiler Design, Operating Systems, Database Management Systems (DBMS), and Computer Networks listed **according to the GATE CS 2020 syllabus.**

GeeksforGeeks Sudo GATE Course: Register for Sudo GATE 2020

GATE 2020 SYLLABUS	LEARN	PRACTICE	EXTERNAL RESOURCES
Section 1: Numerical and Verbal Ability • **Numerical Ability :** Numerical computation, numerical estimation, numerical reasoning and data interpretation • **Verbal Ability :** English grammar, sentence completion, verbal analogies, word groups, instructions, critical reasoning and verbal deduction	1. **Numerical Ability :** • Placements 2. **Verbal Ability :** • Placements | English | Error Detection and Correction • Placements | English | Passage/Sentence Re-arrangement • Placements | English | Fill in the Blanks • Placements | English | Comprehension Passages	1. **Numerical Ability :** • Placements 2. **Verbal Ability :** • Placements	1. **Numerical Ability :** • Book – Quantitative Aptitude by R.S. Aggarwal 2. **Verbal Ability :** • Notes – English
Section 2: Mathematics 1. **Discrete Mathematics :** • Propositional and first order logic • Sets, relations, functions, partial orders and lattices. Groups • **Combinatorics:** counting, recurrence relations, generating functions • **Graphs:** connectivity, matching, coloring 2. **Linear Algebra :** • Matrices, determinants • LU decomposition • System of linear equations • Eigenvalues and eigenvectors 3. **Probability :** • Random variables • Mean, median, mode and standard deviation • Uniform, normal, exponential, Poisson and binomial distributions	1. **Discrete Mathematics :** • Representation of Boolean Functions • Properties of Boolean algebra • PDNF and PCNF in Discrete Mathematics • Functional Completeness • Introduction to Propositional Logic Set 1 • Introduction to Propositional Logic Set 2 • Propositional Equivalence • Predicates and Quantifiers Set 1 • Predicates and Quantifiers Set 2 • Some theorems on Nested Quantifiers • Rules of Inference • Consensus theorem • Introduction to Proofs • Combinatorics Basics	1. **Discrete Mathematics :** • Propositional and First Order Logic • Set Theory & Algebra • Combinatorics • Combinatorics | Set 1 • Combinatorics | Set 2 • Graph Theory 2. **Linear Algebra :** • Linear Algebra 3. **Probability :** • Probability 4. **Calculus :** • Calculus	1. **Discrete Mathematics :** • Video – MIT Discrete Mathematics Lectures • Notes – First Order Logic • Book – Schaum's PDF • MIT – Lecture Notes • IISC – Video Lectures • IITM – link for counting • Papers – GATE's Explanation by NPTEL 2. **Linear Algebra :** • MIT – Linear Algebra • Book – Linear Algebra 3. **Probability :**

• Conditional probability and Bayes theorem 4. **Calculus :** • Limits, Continuity and Differentiability • Maxima and Minima. Mean value theorem • Integration	• Pigeonhole Principle • PnC and Binomial Coefficients • Generalized PnC Set 1 • Generalized PnC Set 2 • Inclusion-Exclusion and its various Applications • Corollaries of Binomial Theorem • Introduction of Generating Functions • Generating Functions – Set 2 • Set Theory | Introduction • Set Theory | Set Operations • Power Set and its Properties • Relations and their types • Relations and their representations • Representing Relations • Closure of Relations and Equivalence Relations • Functions | Properties and Types • Inverse functions and composition of functions • Total number of possible functions • Number of possible equivalence relations • Groups • Partial Orders and Lattices • Hasse Diagrams • Graph Theory Basics – Set 1 • Graph Theory Basics – Set 2 • Walks, Trails, Paths, Cycles and Circuits in Graph • Number of nodes and height of binary tree • Graph measurements: length, distance, diameter, eccentricity, radius, center • Graph Isomorphisms and Connectivity • Planar Graphs and Graph Coloring • Euler and Hamiltonian Paths		• Book – Probability • Notes – Probability 4. **Calculus :** • MIT – Video Lectures • Notes – Calculus • Calculus

	• Independent Sets, Covering and Matching • Matching (graph theory) • Graph theory practice questions • Recurrence relations • Different types of recurrence relations and their solutions • Types of Recurrence Relations – Set 2 2. **Linear Algebra :** • Matrix Introduction • Different operations on matrices • L U Decomposition • Doolittle Algorithm : LU Decomposition • System of Linear Equations • Eigen Values and Eigen Vectors 3. **Probability :** • Probability • Random Variables • Mean, Variance And Standard Deviation • Law of total probability • Bayes's formula for Conditional Probability • Probability Distributions Set 1 (Uniform Distribution) • Probability Distributions Set 2 (Exponential Distribution) • Probability Distributions Set 3 (Normal Distribution) • Probability Distributions Set 4 (Binomial Distribution) • Probability Distributions Set 5 (Poisson Distribution) • Hypergeometric Distribution model • Conditional Probability • Covariance and Correlation 4. **Calculus :** • Limits, Continuity and Differentiability • Lagrange's Mean Value Theorem		

	• Mean Value Theorem | Rolle's Theorem • Cauchy's mean value theorem • Indefinite Integrals • Finding nth term of any polynomial sequence • Sequence, Series and Summations • CATEGORY ARCHIVES: ENGINEERING MATHEMATICS • Last Minute Notes – Engineering Mathematics		
Section 3: Algorithms • Searching, sorting, hashing • Asymptotic worst case time and space complexity • **Algorithm design techniques :** greedy, dynamic programming and divide-and-conquer • Graph search, minimum spanning trees, shortest paths	1. **Asymptotic Analysis of Algorithms :** • Analysis of Algorithms | Set 1 (Asymptotic Analysis) • Analysis of Algorithms | Set 2 (Worst, Average and Best Cases) • Analysis of Algorithms | Set 3 (Asymptotic Notations) • Analysis of Algorithms | Set 4 (Analysis of Loops) • Analysis of Algorithm | Set 5 (Amortized Analysis Introduction) • Analysis of algorithms | little o and little omega notations • What does 'Space Complexity' mean? • Articles | Analysis of Algorithms 2. **Recurrence Relations :** • Analysis of Algorithm | Set 4 (Solving Recurrences) • Different types of recurrence relations and their solutions 3. **Divide and Conquer :** • Divide and Conquer | Set 1 (Introduction) • Binary Search • Why is Binary Search	1. **Asymptotic Analysis of Algorithms :** • Analysis of Algorithms 2. **Recurrence Relations :** • Analysis of Algorithms (Recurrences) • Practice Set for Recurrence Relations 3. **Divide and Conquer :** • MergeSort • Divide and Conquer 4. **Greedy Techniques :** • Graph Minimum Spanning Tree • Graph Shortest Paths • Greedy Algorithms 5. **Graph Based Algorithms :** • Graph • Graph Traversals 6. **Dynamic Programing :** • Dynamic Programming 7. **Searching, Sorting and Hashing :** • Searching • Sorting • Hashing 8. **Misc :** • Misc • Commonly Asked Algorithm Interview	**Algorithms :** • Video – GeeksforGeeks Videos • Video – Lectures by Ravindrababu Ravula • MIT – Introduction to Algorithms • Book – CLRS Solutions Manual • Visual – Data Structures and Algorithms. • Notes – Big – O Notation • Notes – Master Theorem • Notes – Extended Master Theorem • Notes – Master Theorem problems and answers

preferred over Ternary Search?

- Merge Sort
- Merge Sort for Linked Lists
- Merge Sort for Doubly Linked List
- How to make Mergesort to perform O(n) comparisons in best case?
- QuickSort
- Iterative Quick Sort
- QuickSort on Singly Linked List
- QuickSort on Doubly Linked List
- When does the worst case of Quicksort occur?
- Why Quick Sort preferred for Arrays and Merge Sort for Linked Lists?
- Write a program to calculate pow(x,n)
- Median of two sorted arrays
- Count Inversions in an array | Set 1 (Using Merge Sort)
- Divide and Conquer | Set 2 (Closest Pair of Points)
- Divide and Conquer | Set 5 (Strassen's Matrix Multiplication)
- Sort a nearly sorted (or K sorted) array
- Search in an almost sorted array
- K-th Element of Two Sorted Arrays
- K'th Smallest/Largest Element in Unsorted Array | Set 2 (Expected Linear Time)
- Searching and Sorting

4. **Greedy Techniques :**
   - Greedy Algorithms | Set 1 (Activity Selection Problem)
   - Job Sequencing Problem | Set 1 (Greedy Algorithm)
   - Greedy Algorithms | Set 3 (Huffman Coding)

Questions | Set 1

- Data Structures and Algorithms | Set 1
- Data Structures and Algorithms | Set 2
- Data Structures and Algorithms | Set 3
- Data Structures and Algorithms | Set 4
- Data Structures and Algorithms | Set 5
- Data Structures and Algorithms | Set 6
- Data Structures and Algorithms | Set 7
- Data Structures and Algorithms | Set 8
- Data Structures and Algorithms | Set 9
- Data Structures and Algorithms | Set 10
- Data Structures and Algorithms | Set 11
- Data Structures and Algorithms | Set 12
- Data Structures and Algorithms | Set 13
- Data Structures and Algorithms | Set 14
- Data Structures and Algorithms | Set 15
- Data Structures and Algorithms | Set 16
- Data Structures and Algorithms | Set 17
- Data Structures and Algorithms | Set 18
- Data Structures and Algorithms | Set 19
- Data Structures and Algorithms | Set 20
- Data Structures and Algorithms | Set 21
- Data Structures and Algorithms | Set 22
- Data Structures and Algorithms | Set 23
- Data Structures and

	• Greedy Algorithms | Set 4 (Efficient Huffman Coding for Sorted Input) • Greedy Algorithms | Set 2 (Kruskal's Minimum Spanning Tree Algorithm) • Greedy Algorithms | Set 5 (Prim's Minimum Spanning Tree (MST)) • Greedy Algorithms | Set 6 (Prim's MST for Adjacency List Representation) • Applications of Minimum Spanning Tree Problem • Greedy Algorithms | Set 7 (Dijkstra's shortest path algorithm) • Greedy Algorithms | Set 8 (Dijkstra's Algorithm for Adjacency List Representation) • Greedy Algorithm to find Minimum number of Coins • Strongly Connected Components • Greedy Algorithms 5. **Graph Based Algorithms :** • Graph and its representations • Breadth First Traversal or BFS for a Graph • Depth First Traversal or DFS for a Graph • Applications of Depth First Search • Detect Cycle in a Directed Graph • Disjoint Set (Or Union-Find) | Set 1 (Detect Cycle in an Undirected Graph) • Detect cycle in an undirected graph • Topological Sorting • Longest Path in a Directed Acyclic Graph • Biconnected Components • Bellman–Ford Algorithm • Floyd Warshall Algorithm • Shortest Path in Directed Acyclic Graph	Algorithms | Set 24 • Data Structures and Algorithms | Set 25 • Data Structures and Algorithms | Set 26 • Data Structures and Algorithms | Set 27 • Data Structures and Algorithms | Set 28 • Data Structures and Algorithms | Set 29 • Data Structures and Algorithms | Set 30 • Data Structures and Algorithms | Set 31 • Data Structures and Algorithms | Set 32 • Data Structures and Algorithms | Set 33 • Data Structures and Algorithms | Set 34 • Data Structures and Algorithms | Set 35	

- Some interesting shortest path questions | Set 1
- Shortest path with exactly k edges in a directed and weighted graph
- Biconnected Components
- Biconnected graph
- Articulation Points (or Cut Vertices) in a Graph
- Check if a graph is strongly connected | Set 1 (Kosaraju using DFS)
- Bridges in a graph
- Transitive closure of a graph
- Graph Algorithms | DFS and BFS | Minimum Spanning Tree | Shortest Paths | Connectivity

6. **Dynamic Programing :**
   - Dynamic Programming | Set 1 (Overlapping Subproblems Property)
   - Dynamic Programming | Set 2 (Optimal Substructure Property)
   - Dynamic Programming | Set 4 (Longest Common Subsequence)
   - Dynamic Programming | Set 8 (Matrix Chain Multiplication)
   - Dynamic Programming | Set 10 (0-1 Knapsack Problem)
   - Dynamic Programming | Set 6 (Min Cost Path)
   - Dynamic Programming | Set 25 (Subset Sum Problem)
   - Dynamic Programming | Set 23 (Bellman–Ford Algorithm)
   - Dynamic Programming | Set 16 (Floyd Warshall Algorithm)
   - Total number of non-decreasing numbers with n digits
   - Vertex Cover Problem | Set 2 (Dynamic Programming Solution for Tree)

- Smallest power of 2 greater than or equal to n
- Travelling Salesman Problem | Set 1 (Naive and Dynamic Programming)
- Travelling Salesman Problem | Set 2 (Approximate using MST)
- Dynamic Programming

7. **Searching, Sorting and Hashing :**
   - Linear Search
   - Linear Search vs Binary Search
   - Selection Sort
   - Bubble Sort
   - Insertion Sort
   - Heap Sort
   - Radix Sort
   - Counting Sort
   - Hashing | Set 1 (Introduction)
   - Hashing | Set 2 (Separate Chaining)
   - Hashing | Set 3 (Open Addressing)
   - Hash Table vs STL Map
   - Advantages of BST over Hash Table
8. **Misc :**
   - Find subarray with given sum | Set 2 (Handles Negative Numbers)
   - Largest subarray with equal number of 0s and 1s
   - Find four elements a, b, c and d in an array such that a+b = c+d
   - Print all subarrays with 0 sum
   - Given an array A[] and a number x, check for pair in A[] with sum as x
   - Union and Intersection of two Linked Lists
   - Find whether an array is subset of another array | Added Method 3
   - Count pairs with given sum

	• Top 20 Hashing Technique based Interview Questions • CATEGORY ARCHIVES: ALGORITHMS • Last Minute Notes – Algorithms		
Section 4: Programming and Data Structures • Programming in C, Recursion • Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs	1. **Programming in C, Recursion :** • C Programming • Recursion • Tail Recursion • Recursive functions 2. **Array, Stack, Queue :** • Arrays • Stack • Queue 3. **Linked Lists :** • Linked List 4. **Trees, Binary search trees, Binary heaps :** • Binary Tree • Binary Search Tree • Binary Heap 5. **Graphs :** • Graph • CATEGORY ARCHIVES: DATA STRUCTURES • CATEGORY ARCHIVES: C • Last Minute Notes – DATA STRUCTURE • Last Minute Notes – C/C++	1. **Programming in C, Recursion :** • Principle of programming languages | Set 1 • C Language • Recursion • C Language | Set 1 • C Language | Set 2 • C Language | Set 3 • C Language | Set 4 • C Language | Set 5 • C Language | Set 6 • C Language | Set 7 • C Language | Set 8 • C Language | Set 9 • C Language | Set 10 2. **Array, Stack, Queue :** • Array • Stack • Queue 3. **Linked Lists :** • Linked List 4. **Trees, Binary search trees, Binary heaps :** • Binary Trees • Tree Traversals • Binary Search Trees • Balanced Binary Search Trees • Heap 5. **Graphs :** • Graph • Graph Traversals • Commonly Asked Data Structure Interview Questions | Set 1	**Programming and Data Structures :** • Video – NPTEL lectures • Visual – Data Structure Visualizations
Section 5: Operating Systems • Processes, threads, CPU scheduling • Inter-process communication, concurrency and	1. **Processes, threads, CPU scheduling :** • What happens when we turn	1. **Processes, threads, CPU scheduling :** • Process Management	**Operating Systems :** • Video – NPTEL Lectures • Video – Lectures by

synchronization, deadlock • Memory management and virtual memory • File systems	on computer? • Introduction of Operating System • Functions of Operating System • Types of Operating Systems • Dual Mode operations in OS • Privileged and Non-Privileged Instructions • 32-bit and 64-bit operating systems • Real time systems • Operating Systems | Need and Functions • Process Management | Introduction • States of a process • Process Table and Process Control Block (PCB) • Process Scheduler • Difference between dispatcher and scheduler • Process Management | CPU Scheduling • Preemptive and Non-Preemptive Scheduling • Program for FCFS Scheduling | Set 1 • Program for FCFS Scheduling | Set 2 (Processes with different arrival times) • Convoy Effect in Operating Systems • Program for preemptive priority CPU scheduling • Program for Round Robin scheduling | Set 1 • Round Robin Scheduling with different arrival times • Program for Shortest Job First (or SJF) scheduling | Set 1 (Non- preemptive) • Program for Shortest Job First (SJF) scheduling | Set 2 (Preemptive) • Shortest Job First scheduling with predicted burst time • Longest Remaining Time	• CPU Scheduling 2. **Inter-process communication, concurrency and synchronization :** • Concurrency and synchronization 3. **Deadlock :** • Deadlock 4. **Main memory management :** • Memory Management 5. **Virtual memory :** • Virtual Memory | Questions 6. **File system and disk scheduling :** • Input Output Systems • UNIX – I Node • Commonly Asked Operating Systems Interview Questions | Set 1 • Operating Systems | Set 1 • Operating Systems | Set 2 • Operating Systems | Set 3 • Operating Systems | Set 4 • Operating Systems | Set 5 • Operating Systems | Set 6 • Operating Systems | Set 7 • Operating Systems | Set 8 • Operating Systems | Set 9 • Operating Systems | Set 10 • Operating Systems | Set 11 • Operating Systems | Set 12 • Operating Systems | Set 13 • Operating Systems | Set 14 • Operating Systems | Set 15 • Operating Systems | Set 16 • Operating Systems | Set 17	Ravindrababu Ravula • Notes – VirginiaTech Univ. Web resource • Notes – Galvin Lecture Slides • Book – William Stallings Practice Problems and Solutions • Notes – User and Kernel Level Threads • Notes – Virtual Memory and Cache • Notes – Segmentation and Paging • Notes – Some Interesting problems on Virtual memory

	First (LRTF) algorithm • Longest Remaining Time First (LRTF) Program • Highest Response Ratio Next (HRRN) Scheduling • Program for Priority Scheduling | Set 1 • Priority Scheduling with different arrival time | Set 2 • Multilevel Queue Scheduling • Multilevel Feedback Queue Scheduling • Multiple-Processor Scheduling • Measure the time spent in context switch • Starvation and Aging in Operating Systems • Introduction of System Call • Operating System | Thread • Threads and its types • Multithreading • Multi threading models • Benefits of Multithreading • Process-based and Thread-based Multitasking • User Level thread Vs Kernel Level thread • Microkernel • Monolithic Kernel and key differences from Microkernel • Difference between multitasking, multithreading and multiprocessing • fork() in C • Boot Block 2. **Inter-process communication, concurrency and synchronization:** • Process Synchronization | Introduction • Operating System | Process Synchronization | Set 2 • Critical Section • Inter Process Communication		

	• IPC using Message Queues • IPC through shared memory • Interprocess Communication: Methods • Semaphores in operating system • Mutex vs Semaphore • Lock variable synchronization mechanism • Peterson's Algorithm for Mutual Exclusion | Set 1 (Basic C implementation) • Peterson's Algorithm for Mutual Exclusion | Set 2 (CPU Cycles and Memory Fence) • Peterson's Algorithm (Using processes and shared memory) • Readers-Writers Problem | Set 1 (Introduction and Readers Preference Solution) • Reader-Writers solution using Monitors • Producer Consumer Problem using Semaphores | Set 1 • Producer-Consumer solution using Semaphores in Java | Set 2 • Sleeping Barber problem • Process Synchronization | Monitors • Dining-Philosophers Solution Using Monitors • Dining Philosopher Problem Using Semaphores • Dekker's algorithm • Bakery Algorithm • Priority Inversion : What the heck ! • What's difference between Priority Inversion and Priority Inheritance ? • Deadlock, Starvation, and Livelock 3. **Deadlock :** • Process Management | Deadlock Introduction		

	• Program for Deadlock free condition • Deadlock Prevention And Avoidance • Deadlock Detection And Recovery • Resource Allocation Graph (RAG) • Banker's Algorithm • Program for Banker's Algorithm | Set 1 (Safety Algorithm) • Banker's Algorithm : Print all the safe state • Deadlock detection algorithm • Methods of resource allocation to processes by operating system 4. **Main memory management :** • Mapping virtual address to physical addresses • Logical vs Physical Address in Operating System • Paging • Page Table Entries • Inverted Page Table • Segmentation • Memory Management | Partition Allocation Method • Program for First Fit algorithm in Memory Management • Program for Next Fit algorithm in Memory Management • Non-Contiguous Allocation • Fixed (or static) Partitioning • Variable (or dynamic) Partitioning • Working with Shared Libraries | Set 1 • Static and Dynamic Libraries | Set 1 • Buddy System • Buddy System Memory Allocation • Buddy System Memory		

	Deallocation • Allocating kernel memory • Requirements of memory management system 5. **Virtual memory :** • Virtual Memory • Secondary memory – Hard disk drive • Page Fault Handling • Page Replacement Algorithms • Belady's Anomaly • Program for Optimal Page Replacement Algorithm • Second Chance (or Clock) Page Replacement Policy • Techniques to handle Thrashing • What exactly Spooling is all about? • Difference between Spooling and Buffering • Overlays in Memory Management • Swap Space 6. **File system and disk scheduling :** • File Systems • Structures of Directory • File Directory | Path Name • File Access Methods • File Allocation Methods • Operating System | Free space management • Difference between FAT32, exFAT, and NTFS File System • Disk Scheduling Algorithms • Program for SSTF disk scheduling algorithm • CATEGORY ARCHIVES: OPERATING SYSTEMS • Last Minute Notes – Operating Systems		
Section 6: Databases • ER-model, **Relational model :** relational algebra, tuple calculus, SQL	1. **ER-model :** • Database Management System – Introduction | Set 1	1. **ER-model:** • ER and Relational Models 2. **Relational model (relational algebra, tuple calculus):**	**Databases :** • Video – NPTEL Lectures • Notes – Lecture Slides

• Integrity constraints, normal forms • Transactions and concurrency control • File organization, indexing (e.g., B and B+ trees)	• Database Management System Introduction | Set 2 (3-Tier Architecture) • DBMS Architecture 2-Level, 3-Level • Need for DBMS • Advantages of DBMS over File system • Choice of DBMS | Economic factors • Data Abstraction and Data Independence • ER Model • Recursive Relationships • Minimization of ER Diagram • Enhanced ER Model • Mapping from ER Model to Relational Model 2. **Relational model (relational algebra, tuple calculus) :** • Relational Model • Relational Algebra – Overview • DBMS | Anomalies in Relational Model • Relational Model Introduction and Codd Rules • Keys in Relational Model (Candidate, Super, Primary, Alternate and Foreign) • Relational Algebra-Basic Operators • Relational Algebra – Extended Operators • Tupple Relational Calculus • DBMS | How to solve Relational Algebra problems for GATE • DBMS | Row oriented vs. column oriented data stores 3. **Database design (integrity constraints, normal forms) :** • Database Normalization | Introduction • Database Normalization | Normal Forms • Functional Dependency and	• ER and Relational Models 3. **Database design (integrity constraints, normal forms):** • Database Design(Normal Forms) 4. **Query languages (SQL) :** • SQL 5. **Transactions and concurrency control:** • Transactions and concurrency control 6. **File structures (sequential files, indexing, B and B+ trees):** • File structures (sequential files, indexing, B and B+ trees) • Practice questions on B and B+ Trees • Commonly asked DBMS interview questions | Set 1 • Commonly asked DBMS interview questions | Set 2 • Database Management Systems | Set 1 • Database Management Systems | Set 2 • Database Management Systems | Set 3 • Database Management Systems | Set 4 • Database Management Systems | Set 5 • Database Management Systems | Set 6 • Database Management Systems | Set 7 • Database Management Systems | Set 8 • Database Management Systems | Set 9 • Database Management Systems | Set 10 • Database Management Systems | Set 11	Silberschatz, Korth and Sudarshan • Notes – Lecture Slides Raghu Ramakrishnan and Johannes Gehrke • Notes – Stanford DBMS course Lecture Slides • Notes – Jeff Ullman's Lecture Slides • Notes – Canonical Cover • Notes – Indexing • Visual – B Tree • Notes – B+ Tree • Visual – B+ Tree

	Attribute Closure • Finding Attribute Closure and Candidate Keys using Functional Dependencies • Number of possible Superkeys • Lossless Decomposition • Dependency Preserving Decomposition • Lossless Join and Dependency Preserving Decomposition • DBMS | How to find the highest normal form of a relation • DBMS | Minimum relations satisfying 1NF • Equivalence of Functional Dependencies • Armstrong's Axioms in Functional Dependency • Canonical Cover • Denormalization in Databases • Introduction of 4th and 5th Normal form 4. **Query languages (SQL) :** • Structured Query Language (SQL) • Inner VS Outer Join • Having Vs Where Clause • Database Objects • Nested Queries in SQL • Join operation Vs nested query • Indexing in Databases | Set 1 • SQL queries on clustered and non-clustered Indexes • SQL Tutorial 5. **Transactions and concurrency control :** • Concurrency Control - Introduction • Database Recovery Techniques • ACID Properties in DBMS • Log based recovery • DBMS | Why recovery is		

	needed? • Transaction Isolation Levels in DBMS • Concurrency Control | Types of Schedules • DBMS | Types of Recoverability of Schedules and easiest way to test schedule • Conflict Serializability • Precedence Graph For Testing Conflict Serializability • How to test if two schedules are View Equal or not ? • Recoverability of Schedules • Deadlock in DBMS • Starvation in DBMS • Concurrency Control Protocols | Lock Based Protocol • Concurrency Control Protocol | Two Phase Locking (2-PL)-I • Concurrency Control Protocol | Two Phase Locking (2-PL)-II • Concurrency Control Protocol | Two Phase Locking (2-PL)-III • Concurrency Control Protocol | Thomas Write Rule • Concurrency Control Protocols | Timestamp Ordering Protocols • Concurrency Control Protocol | Multiple Granularity Locking • Concurrency Control Protocol | Graph Based Protocol • Introduction to TimeStamp and Deadlock Prevention Schemes • Implementation of Locking in DBMS • DBMS | Challenges of database security		

	6. **File structures (sequential files, indexing, B and B+ trees) :** • Indexing in Databases | Set 1 • File Organization – Set 1 • File Organization – Set 2 (Hashing in DBMS) • File Organization – Set 3 • B-Tree | Set 1 (Introduction) • B-Tree | Set 2 (Insert) • B-Tree | Set 3 (Delete) • Database File Indexing – B+ Tree (Introduction) • RAID • Data Warehousing • Data Mining • Data Replication • CATEGORY ARCHIVES: DBMS • Last Minute Notes – DBMS		
Section 7: Computer Networks • Concept of layering, LAN technologies (Ethernet) • Flow and error control techniques, switching • IPv4/IPv6, routers and routing algorithms (distance vector, link state) • TCP/UDP and sockets, congestion control • Application layer protocols (DNS, SMTP, POP, FTP, HTTP) • Basics of Wi-Fi • **Network security :** authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls	1. **Network Fundamental and Physical layer :** • Basics of Computer Networking • Network goals • Network Topologies • Types of area networks – LAN, MAN and WAN • MANET: Mobile Ad hoc Network • Types of MANET • Types of Transmission Media • Transmission Modes in Computer Networks (Simplex, Half-Duplex and Full-Duplex) • Redundant link problems • Digital Subscriber Line (DSL) • What is Scrambling? • Difference between Unipolar, Polar and Bipolar Line Coding Schemes • Manchester Encoding • Analog to digital conversion • Digital to Analog	1. **Network Fundamental and Physical layer :** • Computer Networks 2. **Data Link layer :** • Data Link Layer 3. **Network layer :** • Network Layer • IP Addressing 4. **Transport layer :** • Transport Layer 5. **Application layer :** • HTTP Non-Persistent & Persistent Connection | Set 2 (Practice Question) • Application Layer 6. **Network security :** • Network Security • Commonly asked Computer Networks Interview Questions | Set 1 • Computer Networks | Set 1 • Computer Networks | Set 2 • Computer Networks | Set 3 • Computer Networks | Set 4 • Computer Networks | Set 5 • Computer Networks | Set 6	**Computer Networks :** • Video – NPTEL Lectures • Video – Lectures by Ravindrababu Ravula • Notes – Lecture Notes IIT Kanpur • Notes – Web Resources on Computer Networks by Tanenbaum • Visual – Sliding Window Animation • Notes – Sliding Window MIT • Notes – IPv4 vs IPv6

	Conversion • Analog to Analog Conversion (Modulation) • Difference between Broadband and Baseband Transmission • Let's experiment with Networking • Layers of OSI Model • TCP/IP Model 2. **Data Link layer :** • Multiple Access Protocols • P2P(Peer To Peer) File Sharing • Framing In Data Link Layer • LAN Technologies | ETHERNET • Ethernet Frame Format • Token Ring frame format • Bit Stuffing • Difference between Byte stuffing and Bit stuffing • Hamming Code • Carrier sense multiple access (CSMA) • Controlled Access Protocols • Back-off Algorithm for CSMA/CD • Collision Detection in CSMA/CD • Efficiency of CSMA/CD • Efficiency Of Token Ring • Computer Networks | Error Detection • Stop and Wait ARQ • Sliding Window Protocol | Set 1 (Sender Side) • Sliding Window Protocol | Set 2 (Receiver Side) • Sliding Window Protocol | Set 3 (Selective Repeat) • Sliding Window protocols Summary With Questions • Program to remotely Power On a PC over the internet using the Wake-on-LAN protocol	• Computer Networks | Set 7 • Computer Networks | Set 8 • Computer Networks | Set 9 • Computer Networks | Set 10 • Computer Networks | Set 11 • Computer Networks | Set 12	

	• Program to calculate the Round Trip Time (RTT) • Introduction of MAC Address • Collision Avoidance in wireless networks • Maximum data rate (channel capacity) for noiseless and noisy channels • Types of switches 3. **Network layer :** • Internetworking • Line Configuration in Computer Networks • Difference between Unicast, Broadcast and Multicast • Collision Domain and Broadcast Domain • IP Addressing | Introduction and Classful Addressing • Network Layer | Introduction and IPv4 Datagram Header • Network Layer | Ipv4 Datagram Fragmentation and Delays • Fragmentation at Network Layer • Internet Protocol v6 | IPv6 • Internet Protocol version 6 (IPv6) Header • IP Addressing | Classless Addressing • Supernetting • Computer Networks | Longest Prefix Matching in Routers • Program to determine class, Network and Host ID of an IPv4 address • C Program to find IP Address, Subnet Mask & Default Gateway • IPv4 classless Subnet equation • Introduction to variable length subnet mask (VLSM) • Network address translation (NAT)		

	• Types of Network address translation (NAT) • Classification of Routing Algorithms – Set 1 • Types of routing – Set 2 • Classes of routing protocols – Set 3 • Distance vector routing v/s Link state routing • Fixed and Flooding Routing algorithms • Routing v/s Routed Protocols • Unicast Routing – Link State Routing • Routing Protocols Set 1 (Distance Vector Routing) • Route Poisoning and Count to infinity problem • Onion Routing • Router on a stick • Internet Control Message Protocol (ICMP) | Computer Networks • Hot Standby Router Protocol (HSRP) • OSPF protocol fundamentals • OSPF protocol States • OSPF router roles and configuration • Root Bridge Election in Spanning Tree Protocol • Types of Spanning Tree Protocol (STP) • EIGRP fundamentals • Features of Enhanced Interior Gateway Routing Protocol (EIGRP) • Routing Information Protocol (RIP) • Routing Interface Protocol (RIP) V1 & V2 • Link state advertisement (LSA) • Administrative Distance (AD) and Autonomous System (AS) • Circuit Switching		

	• Packet Switching and Delays • Differences between Virtual Circuits & Datagram Networks • Computer Network | Circuit Switching VS Packet Switching • Traceroute • How ARP works? • ARP, Reverse ARP(RARP), Inverse ARP(InARP), Proxy ARP and Gratuitous ARP • Packet flow in the same network • Packet flow in different network • Difference between layer-2 and layer-3 switches • What's difference between Ping and Traceroute? • Computer Network | Servers • What is Local Host? 4. **Transport layer :** • Transport Layer responsibilities • Congestion Control • Leaky Bucket Algorithm • TCP | Services and Segment structure • TCP Congestion Control • TCP 3-Way Handshake Process • TCP Connection Establishment • TCP Connection Termination • Error Control in TCP • TCP Timers • TCP flags • TCP Server-Client implementation in C • User Datagram Protocol (UDP) • Differences between TCP and UDP • Multiplexing and Demultiplexing in Transport		

	Layer 5. **Application layer :** • Protocols in Application Layer • DNS (Domain Name Server) | NetWorking • Address Resolution in DNS • DNS Spoofing or DNS Cache poisoning • Why does DNS use UDP and not TCP? • Dynamic Host Configuration Protocol (DHCP) • DHCP Relay Agent • How DHCP server dynamically assigns IP address to a host? • Simple network management protocol (SNMP) • Simple Mail Transfer Protocol (SMTP) • File Transfer Protocol (FTP) • HTTP Non-Persistent & Persistent Connection • Multipurpose Internet mail extension (MIME) • What's difference between http:// and https:// ? • What's difference between HTML and HTTP ? • What's difference between The Internet and The Web ? • Basics of Wi-Fi • Wifi protected setup (WPS) • Wifi protected access (WPA) • LiFi vs. WiFi • Network Devices (Hub, Repeater, Bridge, Switch, Router and Gateways) 6. **Network security :** • Basic Network Attacks • Types of Viruses • Introduction to Firewall • Zone-based firewall • Firewall methodologies		

	• Deniel of Service and Prevention • Cryptography | Introduction to Crypto-terminologies • Denial of Service DDoS attack • Types of DNS Attacks and Tactics for Security • Types of Security attacks | Active and Passive attacks • Birthday attack • Digital Signatures and Certificates • LZW (Lempel–Ziv–Welch) Compression technique • RC4 Encryption Algorithm • RC5 Encryption Algorithm • SHA-512 Hash • RSA Algorithm in Cryptography • RSA Algorithm using Multiple Precision Arithmetic Library • Weak RSA decryption with Chinese-remainder theorem • Implementation of Diffie-Hellman Algorithm • DNA Cryptography • Port security • Unicode • Message Authentication Codes • How message authentication code works? • System security • Hash Functions in System Security • The CIA triad • Image Steganography • Access-lists (ACL) • Data encryption standard (DES) • Difference between AES and DES ciphers • CATEGORY ARCHIVES: COMPUTER NETWORKS • Last Minute Notes –		

	Computer Networks		
Section 8: Computer Organization and Architecture • Machine instructions and addressing modes • ALU, data-path and control unit • Instruction pipelining • **Memory hierarchy:** cache, main memory and secondary storage • I/O interface (Interrupt and DMA mode)	1. **Machine instructions and addressing modes :** • Von Neumann architecture • Basic Computer Instructions • Instruction Formats (Zero, One, Two and Three Address Instruction) • Stack based CPU Organization • General Register based CPU Organization • Single Accumulator based CPU organization • Problem Solving on Instruction Format • Addressing Modes • Machine Instructions • Difference between CALL and JUMP instructions • Simplified Instructional Computer (SIC) • Hardware architecture (parallel computing) • Flynn's taxonomy • Generations of computer • Amdahl's law and its proof 2. **ALU, data-path and control unit :** • Control Unit and design • Hardwired v/s Micro-programmed Control Unit • Hardwired Vs Micro-programmed Control unit | Set 2 • Horizontal micro-programmed Vs Vertical micro-programmed control unit • Synchronous Data Transfer 3. **Instruction pipelining :** • Pipelining | Set 1 (Execution, Stages and Throughput) • Pipelining | Set 2 (Dependencies and Data Hazard) • Pipelining | Set 3 (Types and	**Computer Organization and Architecture :** • Quiz on Microprocessors • Computer Organization and Architecture	**Computer Organization and Architecture :** • Video – NPTEL Lectures • Book – Carl Hamacher • Notes – Pipelining • Notes – Cache Memory • Notes – Cache Associativity

	Stalling) • Different Instruction Cycles • Performance of Computer • Micro-Operation • RISC and CISC • RISC and CISC | Set 2 4. **Cache Memory :** • Memory Hierarchy Design and its Characteristics • Cache Memory • Cache Organization | Introduction • Locality and Cache friendly code • What's difference between CPU Cache and TLB? • Read and Write operations in memory • Memory Interleaving • Introduction to memory and memory units • 2D and 2.5D Memory organization • Types of computer memory (RAM and ROM) • Different Types of RAM • RAM vs ROM 5. **I/O interface (Interrupt and DMA mode) :** • I/O Interface (Interrupt and DMA Mode) • Input-Output Processor • Kernel I/O Subsystem • Memory mapped I/O and Isolated I/O • BUS Arbitration • Priority Interrupts | (S/W Polling and Daisy Chaining) • Asynchronous input output synchronization • Computer Ports • Clusters In Computer Organisation • Human – Computer interaction through the ages • CATEGORY ARCHIVES: COMPUTER		

	ORGANIZATION & ARCHITECTURE		
Section 9: Theory of Computation • Regular expressions and finite automata • Context-free grammars and push-down automata • Regular and context-free languages, pumping lemma • Turing machines and undecidability	1. **Regular expression, langauges, grammar and finite automata :** • Introduction of Theory of Computation • Finite Automata | Introduction • Chomsky Hierarchy • Regular Expressions, Regular Grammar and Regular Languages • Pumping Lemma • Arden's Theorem • How to identify if a language is regular or not • Designing Finite Automata from Regular Expression • NFA with epsilon move to DFA Conversion • Conversion from NFA to DFA • Minimization of DFA • Generating regular expression from finite automata • Union & Intersection of Regular languages with CFL • Designing Deterministic Finite Automata (Set 1) • Designing Deterministic Finite Automata (Set 2) • DFA of a string with at least two 0's and at least two 1's • DFA machines accepting odd number of 0's or/and even number of 1's • DFA for accepting the language L = {$a^n b^m$ | n+m=even} • DFA for Strings not ending with "THE" • Union process in DFA • Concatenation process in DFA • Star Height of Regular Expression and Regular Language	1. **Regular expression, langauges, grammar and finite automata :** • Regular languages and finite automata • Practice problems on finite automata • Practice problems on finite automata | Set 2 2. **Context free langauges, grammar and push down automata :** • Context free languages and Push-down automata 3. **Context Sensitive langauges :** • . 4. **Turing machines and undecidability :** • Recursively enumerable sets and Turing machines • Undecidability • Automata Theory • Automata Theory | Set 1 • Automata Theory | Set 2 • Automata Theory | Set 3 • Automata Theory | Set 4 • Automata Theory | Set 5 • Automata Theory | Set 6	**Theory of Computation :** • Video – NPTEL Lectures • Video – Lectures by Ravindrababu Ravula • Notes – NFA and DFA • Notes – Non Regular language • Notes – PDA • Notes – Turing Machine • Notes – Rice Theorem

	• Mealy and Moore Machines • Difference between Mealy machine and Moore machine 2. **Context free langauges, grammar and push down automata :** • Pushdown Automata • Pushdown Automata Acceptance by Final State • Check if the language is Context Free or Not • Construct Pushdown Automata for given languages • Construct Pushdown automata for L = $\{0^n1^m2^m3^n \mid m,n \geq 0\}$ • Construct Pushdown automata for L = $\{0^n1^m2^{(n+m)} \mid m,n \geq 0\}$ • Construct Pushdown Automata for all length palindrome • NPDA for the language L ={wϵ{a,b}*| w contains equal no. of a's and b's} • NPDA for accepting the language L = $\{a^n b^n \mid n>=1\}$ • NPDA for accepting the language L = $\{a^n b^m c^n \mid m,n>=1\}$ • NPDA for accepting the language L = $\{a^n b^n c^m \mid m,n>=1\}$ • NPDA for accepting the language L = $\{a^m b^{(2m)} \mid m>=1\}$ • NPDA for accepting the language L = $\{a^m b^n c^p d^q \mid m+n=p+q ; m,n,p,q>=1\}$ • Construct Pushdown automata for L = $\{a^{(2*m)}c^{(4*n)}d^n b^m \mid m,n \geq 0\}$ • NPDA for accepting the language L = $\{a^m b^n c^{(m+n)} \mid m,n\geq 1\}$ • NPDA for accepting the language L = $\{a^m b^{(m+n)} c^n \mid m,n\geq 1\}$ • NPDA for accepting the language L = $\{a^{2m} b^{3m} \mid m\geq 1\}$		

- NPDA for accepting the language L = $\{a^m b^{(2m+1)} \mid m \geq 1\}$
- NPDA for L = $\{0^i 1^j 2^k \mid i==j \text{ or } j==k ; i , j , k >= 1\}$
- Closure Properties of Context Free Languages
- Ambiguity in CFG and CFL
- Simplifying Context Free Grammars
- Converting Context Free Grammar to Chomsky Normal Form
- Converting Context Free Grammar to Greibach Normal Form
- Relationship between grammar and language

3. **Context Sensitive langauges :**
   - Context-sensitive Grammar (CSG) and Language (CSL)
4. **Turing machines and undecidability :**
   - Recursive and Recursive Enumerable Languages
   - Turing Machine
   - Halting Problem
   - Turing Machine for addition
   - Turing machine for subtraction
   - Turing Machine for subtraction | Set 2
   - Turing machine for multiplication
   - Turing machine for copying data
   - Construct a Turing Machine for language L = $\{0^n 1^n 2^n \mid n \geq 1\}$
   - Construct a Turing Machine for language L = $\{ww^r \mid w \in \{0, 1\}\}$
   - Construct a Turing Machine for language L = $\{ww \mid w \in \{0,1\}\}$
   - Construct Turing machine for L = $\{a^n b^m a^{(n+m)} \mid n,m \geq 1\}$
   - Construct a Turing machine for L = $\{a^i b^j c^k \mid i*j = k; i, j, k$

	≥ 1} • Proof that Hamiltonian Path is NP-Complete • Proof that vertex cover is NP complete • Decidability • Decidable and undecidable problems • Undecidability and Reducibility • Computable and non-computable problems • CATEGORY ARCHIVES: THEORY OF COMPUTATION & AUTOMATA • Last Minute Notes – Theory of Computation		
Section 10: Compiler Design • Lexical analysis, parsing, syntax-directed translation • Runtime environments • Intermediate code generation	1. **Introduction of Compiler :** • Introduction of Compiler design • Phases of a Compiler • Symbol Table in Compiler • Static and Dynamic Scoping • Generation of Programming Languages • Error Handling in Compiler Design • Error detection and Recovery in Compiler • Linker 2. **Lexical analysis :** • Lexical Analysis • C program to detect tokens in a C program • Fast Lexical Analyzer Generator 3. **Parsing :** • Classification of Context Free Grammars • Ambiguous Grammar • Why FIRST and FOLLOW? • FIRST Set in Syntax Analysis • FOLLOW Set in Syntax Analysis • Program to calculate First	1. **Introduction of Compiler :** • MCQ on Memory allocation and compilation process 2. **Lexical analysis :** • Lexical analysis 3. **Parsing :** • Compiler Theory | Set 1 • Compiler Theory | Set 2 4. **Syntax directed transalation :** • Parsing and Syntax directed translation 5. **Runtime environments :** • . 6. **Intermediate code generation :** • Code Generation and Optimization	**Compiler Design :** • Video – NPTEL Lectures • Video – Lectures by Ravindrababu Ravula • Book – Basics of Compiler Design • Notes – Bivas Mitra IITgp • Notes – LR Parsing • Notes – Syntax Directed Translation • Notes – Intermediate Code Generation

	and Follow sets of given grammar • Introduction to Syntax Analysis • Parsing Set 1 • Parsing Set 2 • Parsing Set 3 • Shift Reduce Parser in Compiler • Classification of top down parsers • Operator grammar and precedence parser 4. **Syntax directed transalation :** • Syntax Directed Translation • S – attributed and L – attributed SDTs in Syntax directed translation 5. **Runtime environments :** • Runtime Environments 6. **Intermediate code generation :** • Intermediate Code Generation • Three address code in Compiler • Detection of a Loop in Three Address Code • Code Optimization • Introduction of Object Code • Data flow analysis in Compiler • CATEGORY ARCHIVES: COMPILER DESIGN • Last Minute Notes – Compiler Design		
Section 11: Digital Logic • Boolean algebra • Combinational and sequential circuits. Minimization • Number representations and computer arithmetic (fixed and floating point)	1. **Introduction of Boolean Algebra and Logic Gates :** • Logic Gates • Properties of Boolean algebra • Minimization of Boolean Functions • Representation of Boolean Functions • Canonical and Standard Form • Functional Completeness	**Digital Logic :** • Digital Logic (101) • Number representation	**Digital Logic :** • Video – NPTEL Lectures • Video – Lectures by Ravindrababu Ravula • Notes – Number System-Swarthmore • Notes – IEEE Standard 754 Floating Point Numbers

	• K-Map • Implicants in K-Map • PDNF and PCNF • Variable entrant map (VEM) • Consensus theorem • Difference between combinational and sequential circuit 2. **Combinational Circuits :** • Half Adder • Full Adder • Half Subtractor • Full Subtractor • Half Adder and Half Subtractor using NAND NOR gates • Encoders and Decoders • Encoder • Binary Decoder • Combinational circuits using Decoder • Multiplexers • Carry Look-Ahead Adder • Parallel Adder & Parallel Subtractor • BCD Adder • Magnitude Comparator • BCD to 7 Segment Decoder • Programmable Logic Array • Programming Array Logic • Read-Only Memory (ROM) • Static Hazards 3. **Sequential Circuits :** • Introduction of Sequential Circuits • Flip-flop types and their Conversion • Synchronous Sequential Circuits • Counters • Ring Counter • n-bit Johnson Counter • Ripple Counter • Design counter for given sequence		

	• Master Slave JK Flip Flop • Asynchronous Sequential Circuits • Shift Registers • Design 101 sequence detector • Amortized analysis for increment in counter 4. **Number Representation and Computer Airthmetic :** • Number System and base conversions • Code Converters – BCD(8421) to/from Excess-3 • Code Converters – Binary to/from Gray Code • Program for Decimal to Binary Conversion • Program for Binary To Decimal Conversion • Program for Decimal to Octal Conversion • Program for Octal to Decimal Conversion • Program for Hexadecimal to Decimal Conversion • Computer Arithmetic | Set – 1 • Computer Arithmetic | Set – 2 • Floating Point Representation • What's difference between 1's Complement and 2's Complement? • Booth's Algorithm • Restoring Division Algorithm For Unsigned Integer • Non-Restoring Division For Unsigned Integer • CATEGORY ARCHIVES: DIGITAL ELECTRONICS & LOGIC DESIGN • Last Minute Notes – Digital Electronics		

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