



GeeksforGeeks

COMPETITIVE PROGRAMMING



Detailed
Course Syllabus

CONTENTS

CP - PREREQUISITE

CP & Algorithms

- Importance & Motivation of CP
- Time and Space Complexities in CP

- Analysis of Algorithms(Background)
- Asymptotic Analysis
- Order of Growth
- Best, Average and Worst cases
- Asymptotic Notation
- Big O Notation
- Space Complexity

Practice Problems

- Analysis of Common Techniques

- Analysis of Common loops
- Analysis of multiple loops
- Analysis of Linear Search

Practice Problems

Practice Contest

DSA Part I

- Arrays

- Introduction to Arrays
- Array Types
- Operations on Arrays (Part 1)
- Operations on Arrays (Part 2)
- Stock Buy and Sell Problem (Part 1)
- Stock Buy and Sell problem (Part 2)
- Move Zeros to End
- Sliding Window Technique
- Prefix Sum
- Equilibrium Point

Practice Problems

- Matrix

- Multidimensional array in CPP
- Matrix in Snake Pattern
- Matrix Boundary Traversal
- Transpose of a Matrix

Practice Problems

- Recursion

- Recursion Introduction
- Applications of Recursion
- Tail Recursion
- Writing Base Cases in Recursion
- Rope Cutting Problem

Practice Problems

CONTENTS

- Hashing

- Introduction to Hashing
- Direct Address Table
- Hashing Functions
- Collision Handling
- Chaining
- Implementation of Chaining
- Open Addressing
- Double Hashing
- Implementation of Open Addressing
- Chaining vs Open Addressing
- Count Distinct Elements

Practice Problems

- String

- Introduction to String
- Strings in C++
- Palindrome Check
- Check if a String is Subsequence of Other

Practice Problems

- Searching

- Binary Search (Iterative)
- Binary Search (Recursive)
- Analysis of Binary Search
- Square root
- Find a Peak Element
- Two Pointers Approach

Practice Problems

- Sorting

- Overview of sorting algorithm
- Stability in Sorting Algorithm
- Bubble Sort
- Selection Sort
- Insertion Sort
- Merge sort introduction
- Merge Sorting Algorithm
- Merge function of Merge sort
- Merge Sort Analysis
- Quick Sort Introduction
- QuickSort using Lomuto Partition
- QuickSort using Hoare Partition
- QuickSort analysis
- Space Analysis of QuickSort
- Choice of pivot and worst case of quick sort
- Tail call elimination in QuickSort

Practice Problems

Practice Contest

CONTENTS

DSA Part II

- Stack

- Stack Data Structure
- Applications of Stack
- Balanced Parenthesis
- Stock span problem

Practice Problems

- Queue & Dequeue

- Queue Data Structure
- Queue in C++ STL
- Queue in Java
- Generate numbers with given digits
- Deque Data Structure
- Deque in C++ STL
- Deque in Java
- ArrayDeque in Java

Practice Problems

- Tree

- Tree Data Structure
- Binary Tree
- Tree Traversal
- Height of Binary Tree
- Size of Binary Tree

Practice Problems

- Binary Search Tree

- Binary Search Tree(Background)
- Binary Search Tree(Introduction)
- Search in BST (Introduction)
- Insert in BST
- Deletion in BST
- Floor in BST
- Ceil in BST
- Self Balancing BST

Practice Problems

- Heap

- Binary Heap Introduction
- Binary Heap Implementation
- Priority Queue in C++
- PriorityQueue in Java

Practice Problems

- Graph

- Introduction to Graph
- Breadth First Search
- Applications of BFS

CONTENTS

- Depth First Search
- Applications of DFS

Practice Problems

- Greedy

- Introduction to Greedy Algorithms
- Activity Selection Problem
- Activity Selection Solution in C++
- Activity Selection Solution in Java

Practice Problems

- Backtracking

- Concepts of Backtracking
- Rat In a Maze

Practice Problems

Practice Contest

DSA Part III

- Dynamic Programming

- Introduction to DP
- Dynamic Programming Memoization
- Dynamic Programming Tabulation
- Longest Common Subsequence (Part 1)
- Longest Common Subsequence (Part 2)
- Variation of LCS
- Variation of LIS (Part 1)
- Variations of LIS (Part 2)
- Longest Increasing Subsequence Problem
- Longest Increasing Subsequence $O(n \log n)$

Practice Problems

- Trie

- Trie Data Structure (Introduction)
- Trie (Representation, Search and Insert)
- Trie Delete

Practice Problems

- Segment & Binary Indexed Tree

- Segment Tree (Introduction)
- Constructing Segment Tree
- Binary Indexed Tree (Introduction)
- Binary Indexed Tree (Prefix Sum)
- Binary Indexed Tree (Construction)

Practice Problems

- Disjoint Set

- Disjoint Set Introduction
- Find and Union Operations on Disjoint Sets
- Union by Rank
- Path Compression

Practice Problems

Practice Contest

CONTENTS

CP BASICS & NUMBER THEORY

Basics

- Starting with CP

- Solving First Competitive Programming Problem
- Ranges of input And Output
- C++ Tricks For Competitive Programming
- Using Typedef and Macros in C++
- IO Manipulation

Practice Problems

- Number Theory Basics

- Floating Point Default Print Format
- Floating point Manipulating Default Format
- Sum of N Natural Numbers
- Sum of Squares
- Factorial of A Number
- Trailing Zeros in Factorial
- Maximum Power Dividing Factorial
- Trailing Zeros in Factorial

Practice Problems

Practice Contest

Number Theory I

- Bit Masking

- Bitwise Operators in CPP (Part 1)
- Bitwise Operators in CPP (Part 2)
- Count set bits
- Check Kth bit is set or not
- Power of Two
- One Odd Occurring
- Two Odd Occurring
- Gray Codes
- Binary To Gray Code
- Gray to Binary
- Power Set using Bitwise

Practice Problems

CONTENTS

- Fibonacci

- Fibonacci Numbers (introduction and Properties)
- More Properties of Fibonacci Numbers
- Fibonacci Divisibility and GCD
- Count Binary Strings With No two Consecutive 1's
- Dudenney's Cow
- Count Ways to Reach n-th Stair
- Fibonacci Implementation
- Sum of Fibonacci Numbers
- Sum of Squares of Fibonacci Numbers
- Fibonacci LogN Implementation
- Pisano's Period
- Fibonacci Mod M

Practice Problems

- Divisors

- All Divisors of a Number
- Numbers with Exactly 3 Divisors
- Count Divisors (Or Factors)
- Count Factors for Multiple Queries
- Sum of Divisors (Includes Multiple Queries)

Practice Problems

- Prime Factorization

- Prime Factors
- Smallest Prime Factors
- Prime Factorization for Multiple Queries

Practice Problems

- Prime Numbers

- Check for Prime
- Sieve of Eratosthenes
- Segmented Sieve

Practice Problems

Practice Contest

Number Theory II

- GCD & LCM

- GCD of Two Numbers
- Euclidean Algorithm (Optimized Implementation)

CONTENTS

- LCM of Two Numbers
- Extended Euclidean Algorithm
- Bezout's Identity
- Linear Diophantine Equation (Check for Solution)
- Linear Diophantine Equation (Find any Solution)

Practice Problems

- Mathematical Principles

- Inclusion Exclusion Principle
- Inclusion Exclusion (Not Conditions)
- Pigeonhole Principle
- Derangements
- Counting Derangements
- Subarray Sum Divisible By Size

Practice Problems

- Number Theoretic Functions

- Euler Totient Function
- Euler Totient (Efficient Implement)
- Properties of Euler Totient Function
- Euler Totient for 1 To n

Practice Problems

- Binomial Coefficients

- Permutation
- Printing all Permutations
- Combinations
- nCr (Simple Method)
- nCr (Recursive Addition Formula)
- $nCr \text{ Mod } p$ for Large Prime

Practice Problems

Practice Contest

Number Theory III

- Catalan Numbers

- Catalan Number
- Catalan Number Implementation (Part 1)
- Catalan Number Implementation (Part 2)
- Count Ways To Reach Grid Top

CONTENTS

- Number of Binary Trees
- Counting Polygon Triangulation
- More Applications of Catalan

Practice Problems

- Modular Arithmetic

- Modular Arithmetic Introduction
- Modular Arithmetic in Competitive Programming
- Ranges of int Types
- Modular Arithmetic Properties
- Modulo Inverse
- Modulo Inverse Using Euler's Theorem
- Working of Euler's Theorem
- Modulo Inverse Using Fermet's Little Theorem
- Working Of Extended Euclidean Algorithm For Inverse
- Modulo Inverse of 1 to N
- Chinese Remainder Theorem (Introduction)
- CRT Efficient Implementation

Practice Problems

- Modular Exponentiation

- Computing Power
- Iterative Power
- Matrix Exponentiation Introduction
- Recursive Solution and Matrix Exponentiation Part 1
- Recursive Solution and Matrix Exponentiation Part 2

Practice Problems

- Combinatorial Game Theory

- Combinational Game Theory Introduction
- Impartial Game Examples
- Grundy Number (Background)
- Mex and Grundy Number
- Grundy number Implementation
- Composite Games
- Sprague Grundy Theorem
- The Game of Nim
- Working of Nim-Sum Formula
- Working of Grundy Number Theorem

Practice Problems

CONTENTS

- Geometric Algorithms

- Orientation of three ordered points
- Line segment Intersection
- Convex Hull Problem
- Gift Wrapping Algorithm (or Jarvis's March)
- CPP Implementation of Jarvis's March algorithm
- Collinear Points in Jarvis's algorithm
- Graham Scan Algorithm for Convex Hull
- Graham Scan Algorithm in C++
- Closest Pair of Points
- Implementation of Closest Pair in C++
- Working of Closest Pair Algorithm
- Sweep Line Algorithm for Any Two Intersection
- Sweep Line Implementation

Practice Problems

- Miscellaneous Problems

Practice Contest

RECURSION AND BACKTRACKING

- Recursion

- Generate all the balanced string of parentheses for given length
- Generate all passwords of given length
- Distinct Way to write N as sum of positive integers
- Number of Paths in a Grid
- Minimum Path sum in a Grid
- Binomial Coefficient
- Text Pattern Matching

Practice Problems

- Contest - Recursion

- Backtracking

- Sudoku | Backtracking
- N-Queen | Backtracking
- Rat in a maze | Backtracking
- search a word in a grid | Backtracking
- Odd-Even | Backtracking
- The knight's Tour | Backtracking

Practice Problems

Practice Contest

CONTENTS

DIVIDE AND CONQUER - CP

- Binary Search

- Binary Search in CP
- Which Container provides BS and implementation
- Faster Implementation of BS and Concept of Invariants
- Binary search on real numbers Theory
- Need for Monotonic function
- Applications of Binary Search
- Binary Search | Problem 1
- Binary Search | Problem 2
- Binary Search | Problem 3
- Find an element in the array
- Aggressive Cows
- Minimum time to Fulfill all Orders

Practice Problems

- Ternary Search

- Ternary Search
- Need for Parabolic Curve
- In what cases does it fail ?
- Counting Inversions using Merge Sort
- Minimum Range Problem
- Finding Peak in 1-D Array
- Peak in a rotated array

Practice Problems

Practice Contest

STACKS AND QUEUES - CP

- Stack

- Next Greater Element
- Valid parentheses
- Maximum in a stack in $O(1)$ time complexity and $O(n)$ space
- Maximum in a stack in $O(1)$ time complexity and $O(1)$ space
- largest rectangle in a histogram (stack)
- Merge overlapping Intervals (stack)
- Trapping Rain Water (stack)

Practice Problems

CONTENTS

- Queue

- Maximum subsequence sum with some constrained | queue
- maximum in a window | queue

Practice Problems

- Priority Queue

- Minimize the cost (priority queue)
- Minimum number of stops | Priority queue
- Maximum value of the equation | Priority queue
- Skyline problem | Priority queue
- Median of Running stream | priority queue

Practice Problems

Practice Contest

TREES

- Traversals in Tree

- Implementation of Inorder Traversal
- Implementation of Preorder Traversal
- Implementation of Postorder Traversal
- Level Order Traversal
- Level Order Traversal Line by Line (Part 1)
- Level Order Traversal Line by Line (Part 2)

Practice Problems

- Extra Concepts and Problem Solving

- LCA of Binary Tree (Part 1)
- LCA of Binary Tree (Part 2)
- Euler Tour of the tree
- Euler Tour Problem

Practice Problems

Practice Contest

GREEDY - CP

- Greedy

- Greedy Vs DP
- Greedy | Policemen and Thieves
- Greedy | Fractional knapsack
- Greedy | Xor Problem

CONTENTS

- Greedy | Job Sequencing
- Dijkstra on grid
- Greedy | Make Permutation

Practice Problems

Practice Contest

DYNAMIC PROGRAMMING - CP

DP - Basics

- Standard DP Algorithms

- Subset Sum Problem (Recursive Solution)
- Subset Sum Problem (DP Solution)
- Count ways to Reach n'th Stair
- Minimum jumps to reach end
- House Thief
- Kadane's algorithm
- Matrix Chain Multiplication
- Matrix Chain Multiplication (DP Solution)
- Allocate Minimum Pages (Naive Method)
- Allocate Minimum Pages (DP Solution)

Practice Problems

- 2D DP

- Count ways in a grid
- 0-1 knapsack problem DP Solution
- Maximize Points
- Geek Coins

Practice Problems

- Combinatorics

Practice Contest

Advanced Dynamic Programming

- Range DP

- Bitmask DP

- Expected Value

- Expectation DP | Donuts

Practice Problems

CONTENTS

- Probability DP

- Probability DP | Coins

Practice Problems

- Digit DP

- Digit D Occurring K times
- First digit equal to the last digit

Practice Problems

Practice Contest

GRAPHS - CP

- BFS

- Finding the level of each node in the graph
- Snakes and Ladder
- Multisource BFS

Practice Problems

- DFS

- Connected Components in Graph
- Count the number of islands in the grid

Practice Problems

- Topological Sort

- Topological Sort | Introduction
- Topological Sort | Algorithm and Code (Kahn's Algorithm)
- Topological sorting | DFS

Practice Problems

- Lowest Common Ancestor

- LCA | Introduction
- LCA | Checking parent using timer
- LCA | Brute Force
- LCA | Binary Lifting

Practice Problems

- Bridges and Articulation Point

- Bridges and Articulation Point | Introduction
- Bridges and Articulation Point | Concept of Timer
- Bridges | Algorithm and Code
- Articulation Point | Algorithm and Code

Practice Problems

CONTENTS

- Euler Path and Circuit

- Bipartite

- Bipartite Graph - Introduction
- Bipartite Graph | Algorithm and Code

Practice Problems

- Disjoint Sets

- DSU | Introduction
- DSU | Finding Connected Components
- DSU | Detecting Cycles in Undirected Graph
- Problem Solving using DSU 1
- Problem Solving using DSU 2

Practice Problems

- Strongly connected components

- Strongly Connected Components | Introduction and Properties
- Strongly Connected Components | Kosaraju's Algorithm

Practice Problems

- Single Shortest Path

- Shortest Path in an Unweighted Graph
- Dijkstra's Shortest Path Algorithm
- Bellman Ford Shortest Path Algorithm
- Floyd Warshall
- Floyd Warshall

Practice Problems

- Spanning Tree

- Prim's Algorithm/Minimum Spanning Tree
- Implementation of Prim's Algorithm C++
- Implementation of Prim's Algorithm Java
- Kruskal's Algorithm

Practice Problems

Practice Contest

STRING ALGORITHMS - CP

- String

- Naive Pattern Searching
- Improved Naive Pattern Searching for Distinct
- Rabin Karp Algorithm

CONTENTS

- KMP Algorithm (Part 1 : Constructing LPS Array)
- KMP Algorithm (Part 2 : Complete Algorithm)
- Minimum characters to be added at front to make string palindrome
- Z Function
- String suffix structure (advanced)

Practice Problems

Practice Contest

RANGE QUERY PROBLEMS - CP

- Sparse Table

- Sparse Tables | Introduction RMQ
- Sparse Table | Problem 1
- Sparse Table | Problem 2

Practice Problems

- Segment Tree

- Segment Tree | Introduction
- Segment Tree | OR and XOR Problem
- Segment Tree | Finding distinct characters in the given range

Practice Problems

- Merge Sort Tree

- Segment Tree | Merge Sort
- Segment Tree | Inversion Triplet
- Segment Tree | Count number of Non-Decreasing subarrays

Practice Problems

- Lazy Propagation

- Segment Tree | Lazy Propagation Introduction
- Segment Tree | Modified String

Practice Problems

- Fenwick Tree

- Binary Indexed Tree | Inversion Count
- Binary Indexed Tree | Threshold Median

Practice Problems

- Range Queries Problems

Practice Problems

Practice Contest