

Essential Maths for Competitive Programming



Detailed
Course Syllabus

● Module 1

a. Time Complexity

- i. Analysis of Algorithms
- ii. Analysis of common loops, recursion
- iii. Asymptotic Notation
- iv. Space Complexity
- v. Order of Growth

b. Basics

- i. Arithmetic and Geometric Progressions
- ii. Solving First Competitive Programming Problem
- iii. Ranges of Input and Output
- iv. C++ Tricks for Competitive Programming
- v. Using Typedef and Macros in C++
- vi. Sum of first N natural numbers
- vii. Sum of squares of first N natural number
- viii. Factorial of a Number
- ix. Trailing Zeros in Factorial
- x. Maximum Power Dividing Factorial
- xi. Practice Problems

c. Fibonacci

- i. Fibonacci Numbers and Implementation
- ii. Properties of Fibonacci Numbers
- iii. Fibonacci Divisibility and GCD
- iv. Duddenary's Cow
- v. Count Binary Strings With No two consecutive 1's
- vi. Count ways to reach n-th stair
- vii. Sum of Fibonacci and of Fibonacci Squares
- viii. Fibonacci Log N Implementation
- ix. Pisano's Period
- x. Fibonacci Mod M
- xi. Practice Problems

d. Bit Masking

- i. Bitwise OR, AND, XOR
- ii. Bitwise Tricks
- iii. Count Set Bit
- iv. Check Kth bit is set or not
- v. Power of 2
- vi. One odd Occurring

- vii. Two Odd Occurring
- viii. Gray Code
- ix. Power Set Using Bitwise
- x. Practice Problems

● Module 2

a. Prime Numbers

- i. Prime Number and Concept
- ii. Sieve of Erathoneses
- iii. Segmented Sieve
- iv. Practice Problems

b. Prime Factorization

- i. All prime factors of a number
- ii. Least Prime factor concept
- iii. Prime factors for multiple queries
- iv. Practice Problems

c. Divisors

- i. $O(\sqrt{N})$ approach
- ii. Count Divisors
- iii. Numbers with Exactly 3 Divisors
- iv. Count Factors for Multiple queries
- v. Sum of Divisors and Multiple Queries
- vi. Practice Problems

● Module 3

a. GCD & LCM

- i. GCD & LCM Concept
- ii. Basic & Euclidean Algorithm
- iii. Bezout's Identity
- iv. Linear Diophantine Equation
- v. Practice Problems

b. Number Theoretic Functions

- i. Euler Totient
- ii. Properties of Euler Totient function
- iii. Euler Totient for 1 to N
- iv. Practice Problems

c. Mathematics Principles

- i. Inclusion & Exclusion Principle
- ii. Pigeon Hole Principle
- iii. Derangements
- iv. Counting Derangements
- v. Subarray sum divisible by Size
- vi. Practice Problems

● Module 4**a. Modular Operations**

- i. Modular arithmetic Introduction
- ii. Modular Arithmetic in Competitive Coding
- iii. Range of int Type
- iv. Modular Arithmetic Properties
- v. Mod Inverse Concept
- vi. Mod Inverse Using Euler's Theorem
- vii. Working of Euler's Theorem
- viii. Mod Inverse Using Fermat Little
- ix. Mod Inverse from 1 to N
- x. Chinese Remainder Theorem
- xi. CRT Efficient Implementation

b. Modular Exponentiation

- i. Computing Power
- ii. Iterative Power
- iii. Matrix Exponentiation
- iv. Fibonacci Number using Matrix Exponentiation

c. Binomial Concepts

- i. Permutation
- ii. Printing All Permutations
- iii. Combination
- iv. nCr (Simple)
- v. nCr (recursive)
- vi. $nCr \text{ MOD } p$ for large Prime
- vii. Practice Problems

d. Catalan Number

- i. Catalan Number and Concept
- ii. Count Way to reach grid top
- iii. Number of Binary Trees

- iv. Counting Polygon Triangulation
- v. More Problems on Catalan
- vi. Catalan Number Implementation Based Problems

● Module 5

a. Combinatorial Game Theory

- i. Introduction
- ii. Impartial Game Examples
- iii. Grundy Number & its implementation
- iv. Mex & Grundy Number
- v. Composites Game
- vi. Sprague Grundy Theorem
- vii. The Game of Nim
- viii. Working of Nim-Sum & Grundy Number Theorem
- ix. Practice Problems

b. Geometric Algorithms

- i. Orientation of three ordered points
- ii. Line segment Intersection
- iii. Convex Hull Problem
- iv. Gift Wrapping Algorithm (or Jarvis's March)
- v. CPP Implementation of Jarvis's March algorithm
- vi. Collinear Points in Jarvis's algorithm
- vii. Graham Scan Algorithm for Convex Hull
- viii. Graham Scan Algorithm in C++
- ix. Closest Pair of Points
- x. Implementation of Closest Pair in C++
- xi. Working of Closest Pair Algorithm
- xii. Sweep Line Algorithm for Any Two Intersection
- xiii. Practice Problems.

c. Misc. Problems