

🔍 Most Important Math Topics in Meta Hacker Cup

Here's a detailed list grouped by category 📁

🔢 1. Number Theory (very common)

Used in modular arithmetic, divisibility, and combinatorics.

- **GCD / LCM** — Euclid's Algorithm
- **Modular Arithmetic** — $(a * b) \% m$, modular inverse, modular exponentiation
- **Prime Numbers** — Sieve of Eratosthenes, prime factorization
- **Euler's Totient Function** ($\phi(n)$)
- **Fermat's Little Theorem**
- **Chinese Remainder Theorem (CRT)**
- **Power Mod / Modular Multiplication without overflow**
- **Divisors, Multiples, and Factorization problems**

□ *Typical problem example:*

Find number of integers x ($1 \leq x \leq n$) such that $x^k \equiv 1 \pmod{m}$.

□ 2. Combinatorics

Used in counting arrangements, selections, and ways.

- **Factorials and nCr computation (mod M)**
- **Pascal's Triangle**
- **Inclusion–Exclusion Principle**
- **Catalan Numbers** (used in valid bracket / tree problems)
- **Permutations & Combinations under constraints**
- **Pigeonhole Principle**

□ *Typical problem example:*

Count the number of valid strings of length n with no two adjacent equal characters.

⚙️ 3. Algebra

Useful for formula simplification and analytical problem solving.

- **Linear and Quadratic Equations**
- **Polynomials & Roots**

- **Arithmetic and Geometric Progressions (AP/GP)**
- **Modular Linear Equations**
- **Matrix Operations (addition, multiplication, inverse)**
- **Matrix Exponentiation (for fast Fibonacci / recurrence DP)**

□ *Typical problem example:*

Find nth term of recurrence relation using matrix exponentiation.

4. Geometry (2D/3D Computational Geometry)

Very common in higher rounds.

- **Distance between points, midpoint, slope**
- **Convex Hull (Graham Scan / Jarvis March)**
- **Orientation test (cross product sign)**
- **Line intersection**
- **Area of polygon / triangle (Shoelace Theorem)**
- **Circle equations, tangents, and intersections**
- **Closest pair of points problem**

□ *Typical problem example:*

Given N points, find the smallest convex polygon enclosing all of them.

□ **5. Probability and Expected Value**

Appears in medium-hard rounds.

- **Expected value formula:** $E[X] = \sum p_i * x_i$
- **Conditional probability**
- **Combinatorial probability counting**
- **Expected number of steps / trials (Markov chains)**

□ *Typical problem example:*

Expected number of coin tosses until getting k consecutive heads.

6. Discrete Mathematics

Used in graph counting, combinatorial structures, and recurrence relations.

- **Recurrence relations**

- **Generating Functions** (sometimes advanced)
- **Graph theory** (adjacency, degree, Euler's formula)
- **Set theory / Inclusion–Exclusion**
- **Pigeonhole and Matching principles**

💡 7. Modular & Arithmetic Optimization

Used when handling large constraints.

- Fast exponentiation ($a^b \% m$)
- Modular inverse for division in combinatorics
- Handling overflow with 64-bit arithmetic

🏆 Bonus: How Math Appears in Hacker Cup Problems

Here are **real examples** from past contests 🖱️

Year	Problem	Math Concept
2023	<i>Digit Blocks</i>	Modular arithmetic + counting
2022	<i>Second Hands</i>	Combinatorics & counting pairs
2021	<i>Traffic Control</i>	Graph + number properties
2020	<i>Perimetric</i>	Geometry & interval sums
2019	<i>Leapfrog</i>	Simulation + combinatorics
2018	<i>A Tour of Boolea</i>	Set operations + combinatorics

📖 How to Prepare (for you, Sahil)

Since you already like algorithms:

1. Practice **modular arithmetic & combinatorics** first.
2. Learn **geometry formulas** and how to implement them in C++.
3. Solve **math-heavy problems** on:
 - Codeforces (tags: *math*, *number theory*, *geometry*)
 - Hacker Cup practice archive:
<https://www.facebook.com/codingcompetitions/hacker-cup>
 - AtCoder Math contests