Contest Math Cheat Sheet

1. Combinatorics & Counting

- C(n, k) = n! / (k! * (n-k)!)
- Pascal’s Rule: C(n, k) = C(n-1, k-1) + C(n-1, k)
- Symmetry: C(n, k) = C(n, n-k)
- Sum over k: Σ_{k=0}^n C(n, k) = 2^n
- Sum over n: Σ_{m=0}^n C(m, k) = C(n+1, k+1)
- Stars & Bars: Allow empty: C(n+k-1, k-1), No empty: C(n-1, k-1)
- Catalan Numbers: Cat(n) = (1 / (n+1)) * C(2n, n)

2. Number Theory

- LCM(a, b) = (a * b) / GCD(a, b)
- (a+b) mod m = (a mod m + b mod m) mod m
- (a-b) mod m = (a mod m - b mod m + m) mod m
- (a*b) mod m = (a mod m * b mod m) mod m
- Fast exponentiation: O(log b)
- Fermat: a^(p-1) ≡ 1 (mod p) if p prime
- Mod inverse (prime p): a^(p-2) mod p
- Chinese Remainder Theorem: solve congruences when moduli coprime

3. Algebra & Sums

- AP sum: S_n = n/2 * (2a + (n-1)d)
- GP sum: S_n = a * (r^n - 1) / (r - 1)
- Sum first n: n(n+1)/2
- Sum squares: n(n+1)(2n+1)/6
- Sum cubes: [n(n+1)/2]^2

4. Probability

- P(A ∪ B) = P(A) + P(B) - P(A ∩ B)
- Independent: P(A ∩ B) = P(A) * P(B)
- Conditional: P(A|B) = P(A ∩ B) / P(B)

5. Graph & Paths

- Grid paths (no obstacles): C(r+c, r)
- Floyd-Warshall: O(n^3)

- Dijkstra: O((n+m) log n)

6. Geometry

- Heron’s formula: A = sqrt(s(s-a)(s-b)(s-c)), s = (a+b+c)/2
- Distance 2D: sqrt((x2-x1)^2 + (y2-y1)^2)
- Point-line dist: |Ax0 + By0 + C| / sqrt(A^2+B^2)