CP Math & Geometry Cheat Sheet

Compiled for Competitive Programming

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Contents

1 Equations ()

1.1 Linear Equation ( )

Equation: $ax + b = 0 \implies x = -\frac{b}{a}$.

1.2 Systems of Equations ( )

Cramer's Rule for $a_1x + b_1y = c_1$ and $a_2x + b_2y = c_2$:

- $D = a_1b_2 - a_2b_1$
- $D_x = c_1b_2 - c_2b_1, \quad D_y = a_1c_2 - a_2c_1$
- $x = \frac{D_x}{D}, \quad y = \frac{D_y}{D}$

2 Laws of Exponents ()

- **Product Rule:** $a^m \times a^n = a^{m+n}$
- **Quotient Rule:** $\frac{a^m}{a^n} = a^{m-n}$
- **Power Rule:** $(a^m)^n = a^{mn}$
- **Negative Exponent:** $a^{-n} = \frac{1}{a^n}$

3 Quadratic Equations ( )

For $ax^2 + bx + c = 0$:

- **Quadratic Formula:** $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
- **Discriminant** (D)**:** $b^2 - 4ac$

4 Progressions ()

4.1 Arithmetic Progression (AP)

- n-th term: $a_n = a + (n-1)d$
- Sum: $S_n = \frac{n}{2}[2a + (n-1)d]$

4.2 Geometric Progression (GP)

- n-th term: $a_n = ar^{n-1}$
- Sum $(r > 1)$: $S_n = \frac{a(r^n - 1)}{r - 1}$

5 Geometry ()

- **Euclidean Distance:** $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
- **Manhattan Distance:** $|x_1 - x_2| + |y_1 - y_2|$
- **Shoelace Formula (Area):** $\frac{1}{2}|\sum(x_i y_{i+1} - y_i x_{i+1})|$

6 Logarithms ()

$log_a(b) = c \iff a^c = b$. In CP, $O(\log N)$ is the complexity of Binary Search.

- $\log_a(xy) = \log_a x + \log_a y$
- $\log_a(x/y) = \log_a x - \log_a y$
- $\log_a(x^k) = k \log_a x$
- Base Change: $\log_2 N = \frac{\log_{10} N}{\log_{10} 2}$

Any algorithm that repeatedly halves the input size has a time complexity of $O(\log N)$.

- **Binary Search:** Reduces range from N to 1 in $\log_2 N$ steps.
- **Number of Digits:** To find the number of digits in N, use $\lfloor \log_{10} N \rfloor + 1$.