

1. Exponents & Logarithms

Law of Exponents

$$\begin{aligned}
 a^m \cdot a^n &= a^{m+n} \\
 \frac{a^m}{a^n} &= a^{m-n} \\
 (a^m)^n &= a^{mn} \\
 (ab)^n &= a^n b^n \\
 a^{-n} &= \frac{1}{a^n}, \quad a^0 = 1
 \end{aligned}$$

Logarithm Properties

$$\begin{aligned}
 \log_b(xy) &= \log_b x + \log_b y \\
 \log_b\left(\frac{x}{y}\right) &= \log_b x - \log_b y \\
 \log_b(x^k) &= k \log_b x \\
 \text{Change of base: } \log_b x &= \frac{\log_c x}{\log_c b}
 \end{aligned}$$

2. Polynomials & Factoring

Special Products

$$\begin{aligned}
 (a \pm b)^2 &= a^2 \pm 2ab + b^2 \\
 a^2 - b^2 &= (a - b)(a + b) \\
 (a \pm b)^3 &= a^3 \pm 3a^2b + 3ab^2 \pm b^3 \\
 a^3 \pm b^3 &= (a \pm b)(a^2 \mp ab + b^2)
 \end{aligned}$$

Quadratic Formula

For $ax^2 + bx + c = 0$ ($a \neq 0$):

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Discriminant $\Delta = b^2 - 4ac$:

- $\Delta > 0$: Two real roots
- $\Delta = 0$: One repeated root
- $\Delta < 0$: Two complex roots

3. Sequences & Series

Arithmetic Progression (AP)

$$\begin{aligned}
 a_n &= a_1 + (n - 1)d \\
 S_n &= \frac{n}{2}[2a_1 + (n - 1)d] \\
 S_n &= \frac{n}{2}(a_1 + a_n)
 \end{aligned}$$

Geometric Progression (GP)

$$\begin{aligned}
 a_n &= a_1 r^{n-1} \\
 S_n &= \frac{a_1(1-r^n)}{1-r} \quad (r \neq 1) \\
 S_\infty &= \frac{a_1}{1-r} \quad (|r| < 1)
 \end{aligned}$$

4. Complex Numbers

Fundamentals

$$\begin{aligned}
 i^2 &= -1, \quad i^3 = -i, \quad i^4 = 1 \\
 \text{Standard form: } z &= a + bi \\
 \text{Conjugate: } \bar{z} &= a - bi \\
 \text{Magnitude: } |z| &= \sqrt{a^2 + b^2}
 \end{aligned}$$

5. Binomial Theorem

Expansion

$$(x + y)^n = \sum_{k=0}^n \binom{n}{k} x^{n-k} y^k$$

Binomial Coefficient:

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

General term: $T_{k+1} = \binom{n}{k} x^{n-k} y^k$

6. Matrices & Determinants

2x2 Inverse & Determinant

For $A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$:

$$\det(A) = ad - bc$$

$$A^{-1} = \frac{1}{ad - bc} \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}$$