

1. Exponents and Logarithms

$$\begin{aligned}
 a^m \cdot a^n &= a^{m+n} & \log_b(xy) &= \log_b x + \log_b y \\
 \frac{a^m}{a^n} &= a^{m-n} & \log_b\left(\frac{x}{y}\right) &= \log_b x - \log_b y \\
 (a^m)^n &= a^{mn} & \log_b(x^k) &= k \log_b x \\
 a^{-m} &= \frac{1}{a^m} & \log_b a &= \frac{\log_c a}{\log_c b}
 \end{aligned}$$

2. Quadratic Equations

For $ax^2 + bx + c = 0$, the roots are given by the quadratic formula:

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

Discriminant (Δ):

- $\Delta > 0$: Two distinct real roots.
- $\Delta = 0$: Exactly one real root (repeated).
- $\Delta < 0$: Two complex conjugate roots.

3. Polynomials and Factoring

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

Binomial Theorem:

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

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

4. Sequences and Series

Arithmetic Progression (AP):

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

Geometric Progression (GP):

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

5. Complex Numbers

Let $z = a + bi$ where $i^2 = -1$.

- **Conjugate:** $\bar{z} = a - bi$
- **Magnitude:** $|z| = \sqrt{a^2 + b^2}$
- **Euler's Formula:** $e^{i\theta} = \cos \theta + i \sin \theta$