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1. Exponents and Logarithms

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

2. Quadratic Equations

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

Quadratic Formula:

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

Discriminant (Δ):

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

Vieta's Formulas:

$$\text{Sum} = x_1 + x_2 = -\frac{b}{a}, \quad \text{Product} = x_1 x_2 = \frac{c}{a}$$

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:

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

4. Sequences and Series

Arithmetic Sequence:

$$a_n = a_1 + (n - 1)d$$

$$S_n = \frac{n}{2}[2a_1 + (n - 1)d]$$

Geometric Sequence:

$$a_n = a_1 r^{n-1}$$

$$S_n = \frac{a_1(1 - r^n)}{1 - r}, \quad r \neq 1$$

5. Complex Numbers

Let $z = a + bi = r(\cos \theta + i \sin \theta) = re^{i\theta}$.

Euler's Formula:

$$e^{i\theta} = \cos \theta + i \sin \theta$$

De Moivre's Theorem:

$$(r(\cos \theta + i \sin \theta))^n = r^n(\cos(n\theta) + i \sin(n\theta))$$