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1. Exponents & Logarithms

Exponents Rules:

$$a^m \cdot a^n = a^{m+n} \qquad \frac{a^m}{a^n} = a^{m-n}$$
$$(a^m)^n = a^{m \cdot n} \qquad (ab)^n = a^n b^n$$
$$a^{-n} = \frac{1}{a^n} \qquad a^{1/n} = \sqrt[n]{a}$$

Logarithms Rules:

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

2. Polynomials & Factoring

Special Products:

$$(a \pm b)^2 = a^2 \pm 2ab + b^2$$
$$a^2 - b^2 = (a - b)(a + b)$$
$$(a \pm b)^3 = a^3 \pm 3a^2 b + 3ab^2 \pm b^3$$
$$a^3 \pm b^3 = (a \pm b)(a^2 \mp ab + b^2)$$

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

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

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

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

3. Sequences & Series

Arithmetic Sequence (AP):

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

Geometric Sequence (GP):

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

4. Complex Numbers

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

- **Conjugate:** $\bar{z} = a - bi$
- **Modulus:** $|z| = \sqrt{a^2 + b^2}$
- **Polar Form:** $z = r(\cos\theta + i\sin\theta) = re^{i\theta}$
- **De Moivre's Theorem:**

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

5. Matrices & Determinants

For a 2×2 matrix $A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$:

- **Determinant:**

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

- **Inverse Matrix:**

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

Properties:

$$(AB)^{-1} = B^{-1}A^{-1}, \quad (A^T)^T = A$$

6. Binomial Theorem

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

Where the binomial coefficient is defined as:

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

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