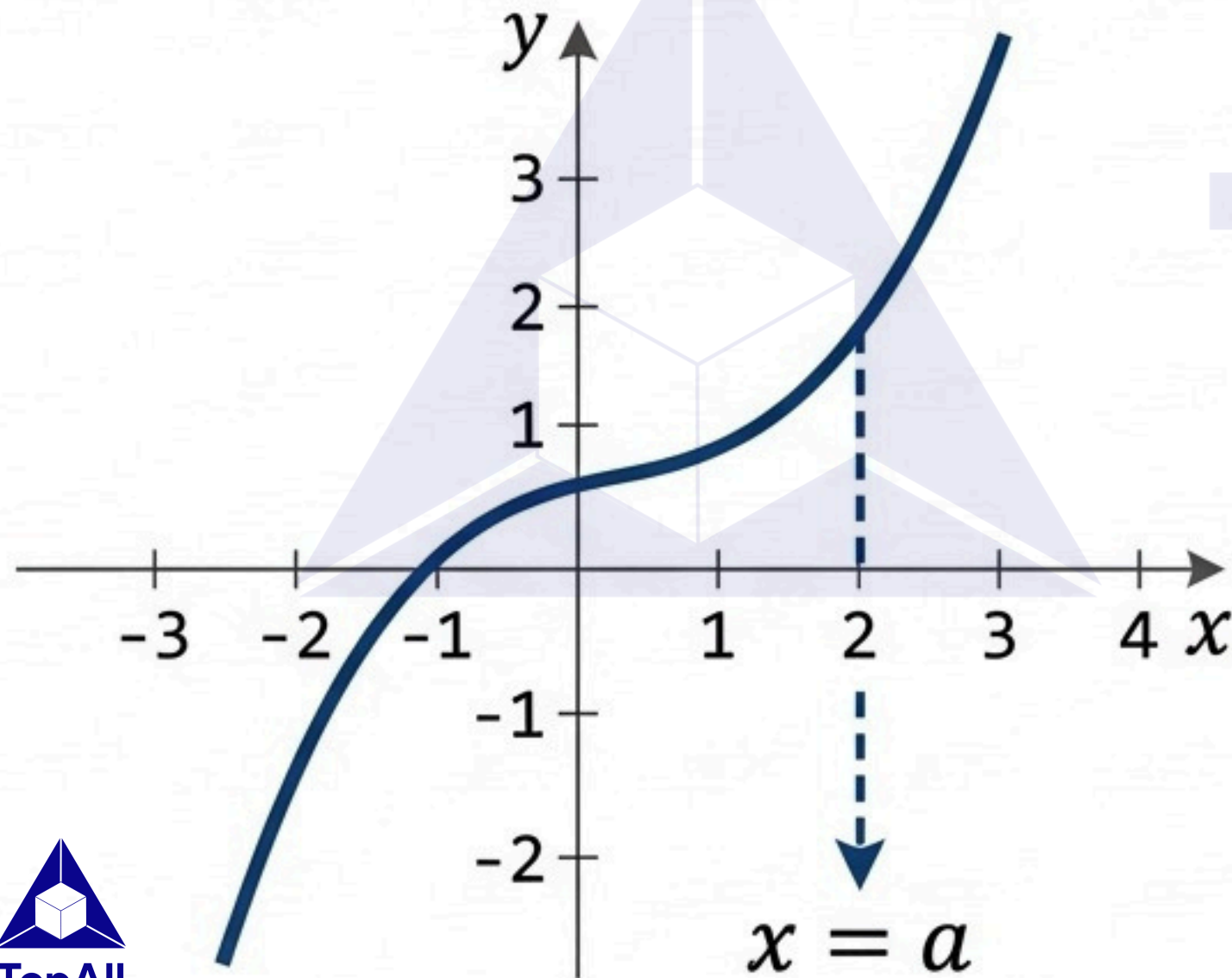


POLYNOMIAL AND RATIONAL LIMITS

Mastering Substitution, Factorisation, and the 0/0 Form

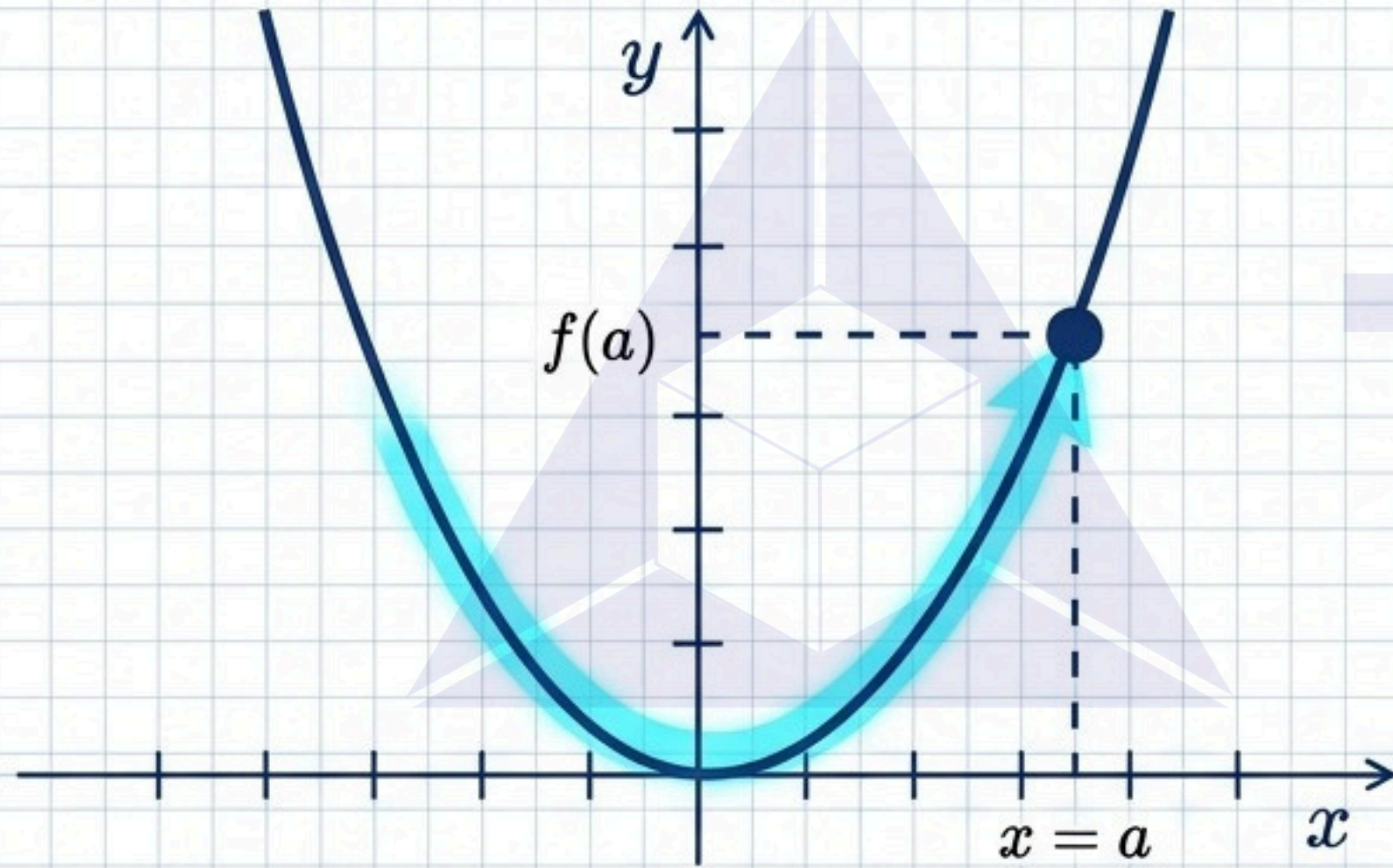


$$f(x) = \frac{\cancel{(x - a)} \cdot g_1(x)}{\cancel{(x - a)} \cdot h_1(x)}$$



Limit Resolved

Direct Substitution for Polynomials



Formula Bank

Rule:

$$\lim_{x \rightarrow a} f(x) = f(a)$$

Where:

$$f(x) = a_0 + a_1(x) + a_2(x^2) + \dots + a_n(x^n)$$

Always plug it in first. Polynomials are continuous and well-behaved; the limit is always just the function evaluated at a .

The 0/0 Form & Factorisation

X-ray

$$f(x) = \frac{g(x)}{h(x)}$$

Substitute
 $x = a$

$$0 / 0$$

Reveal
Factor

$$f(x) = \frac{\cancel{(x-a)} g_1(x)}{\cancel{(x-a)} h_1(x)}$$

Substitution Result	Diagnosis	Next Action
Finite / Finite	Valid Real Number	Limit is this exact value.
Finite / 0	Vertical Asymptote	Limit Does Not Exist.
0 / 0	Indeterminate Form	Factorize and Cancel!



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The Rational Arsenal

Standard formulas to bypass complex polynomial division.

Rational Limit Rule

$$\lim_{x \rightarrow a} \left[\frac{g(x)}{h(x)} \right] = \frac{g(a)}{h(a)}$$

Condition: $h(a) \neq 0$

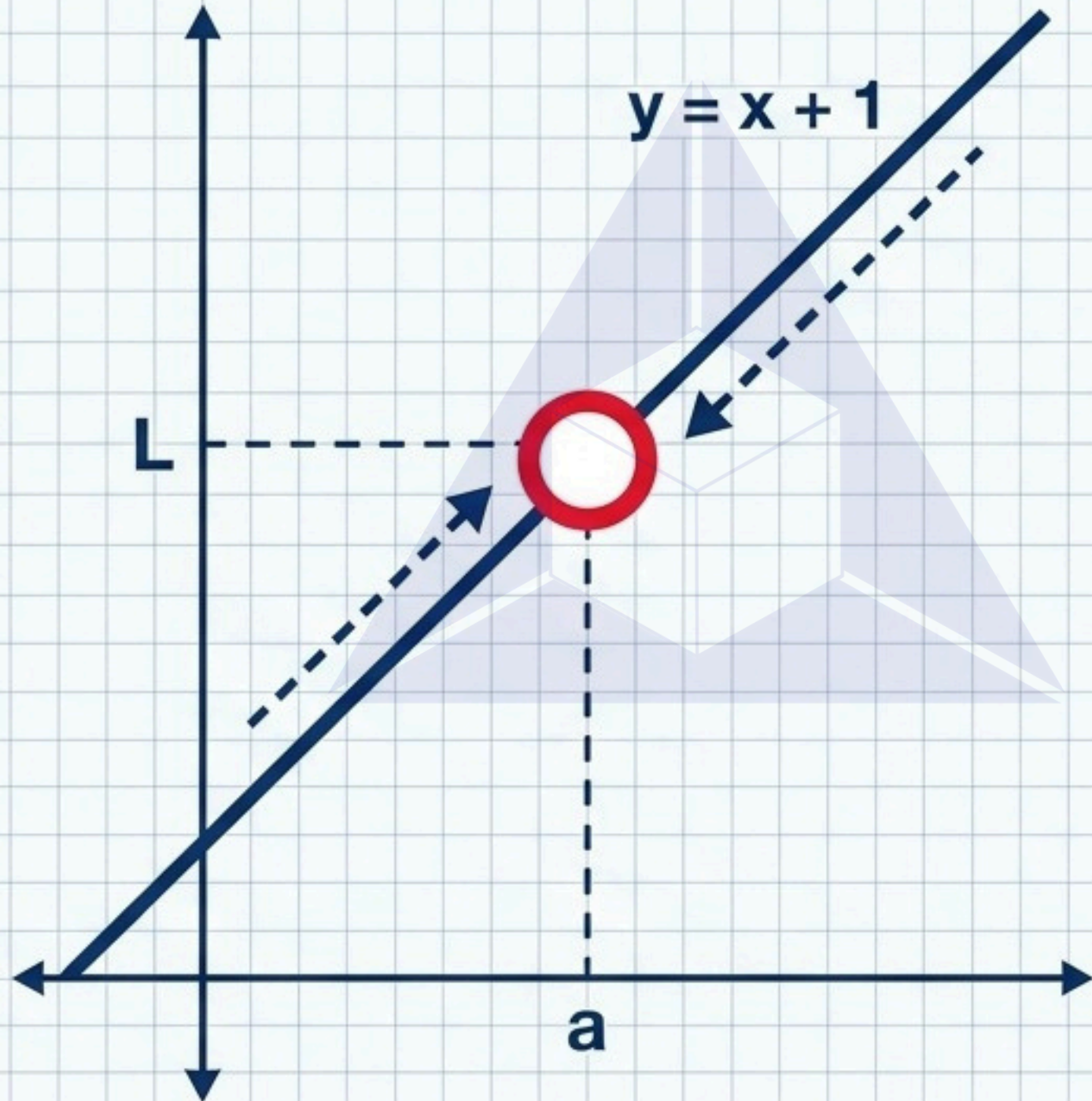
Standard Limit Rule (Theorem 2)

$$\lim_{x \rightarrow a} \left[\frac{x^n - a^n}{x - a} \right] = n \cdot a^{n-1}$$



Shortcut unlocked:
Theorem 2 works for ANY
rational number n .

The Indeterminate Trap



TRAP: 0/0 is NOT the answer. It does NOT equal 0, 1, or Infinity!

0/0 is an Indeterminate Form. It is an algebraic error code that simply means "Do more work."

The graph has a hole, but the path approaching it (the limit) still exists. You must find and cancel the hidden factor.

Mini Application: Higher Power Rationals

Evaluate: $\lim_{x \rightarrow 1} \left[\frac{(x^{10} - 1)}{(x^{15} - 1)} \right]$

Step 1: The Test

Substitute $x=1$

$$\text{Result: } \frac{(1^{10} - 1)}{(1^{15} - 1)} = \frac{0}{0}$$

⚠ Trap Avoided

Step 2: The Setup

Divide numerator and denominator by $(x-1)$ to force Theorem 2 standard form.

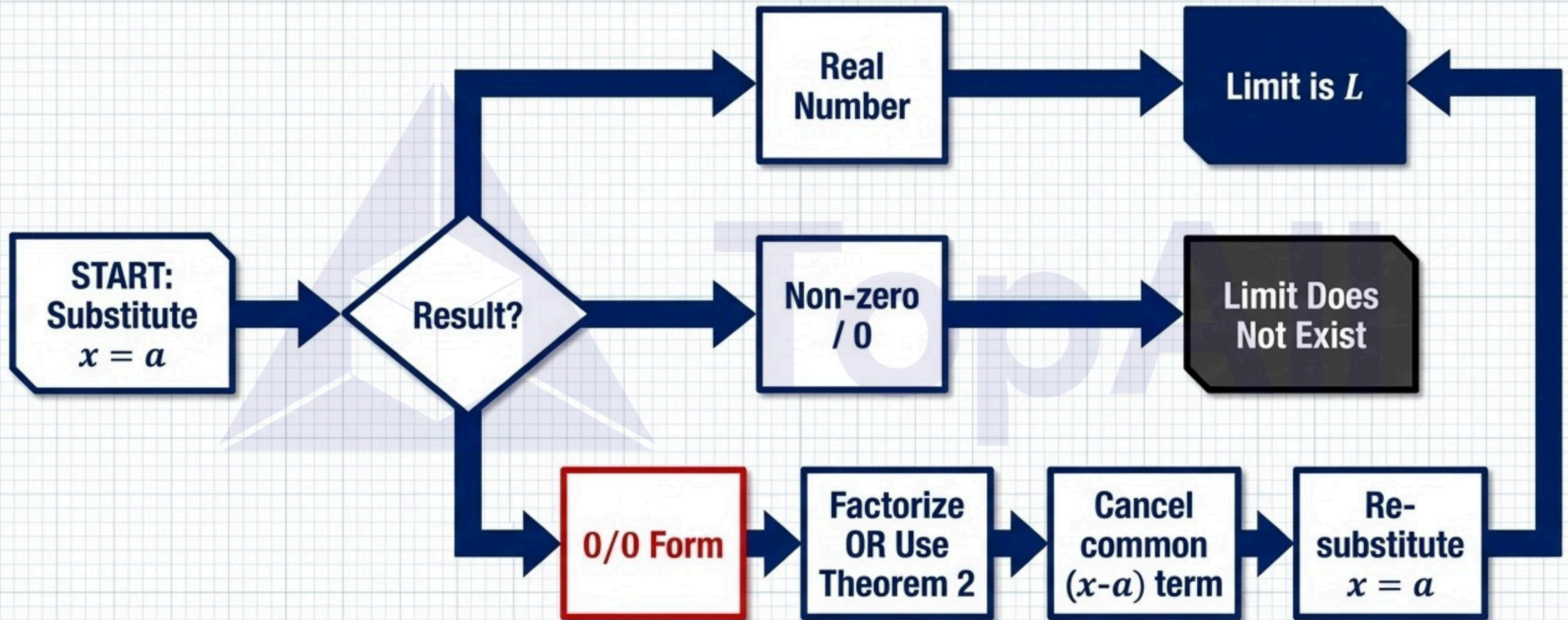
$$\frac{[(x^{10} - 1) / (x - 1)]}{[(x^{15} - 1) / (x - 1)]}$$

Step 3: The Execution

Apply $n \cdot a^{(n-1)}$ to top and bottom independently.

$$\begin{aligned} & [10 * (1)^9] / [15 * (1)^{14}] \\ &= 10 / 15 \\ &= \boxed{2 / 3} \end{aligned}$$

The Master Flowchart (Revision Card)



The Ultimate Playbook: Substitute -> If 0/0, Factor -> Cancel -> Limit.



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