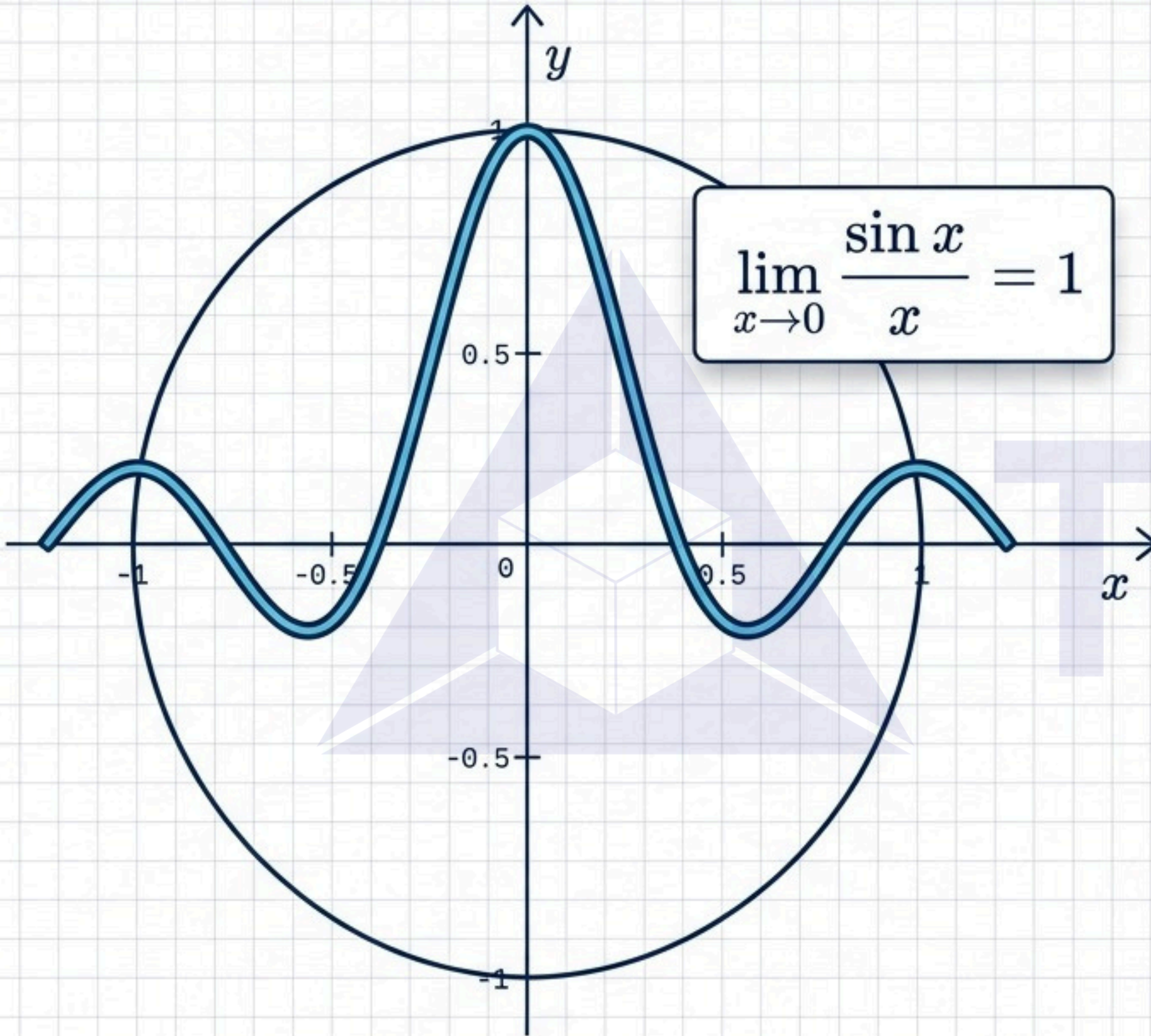




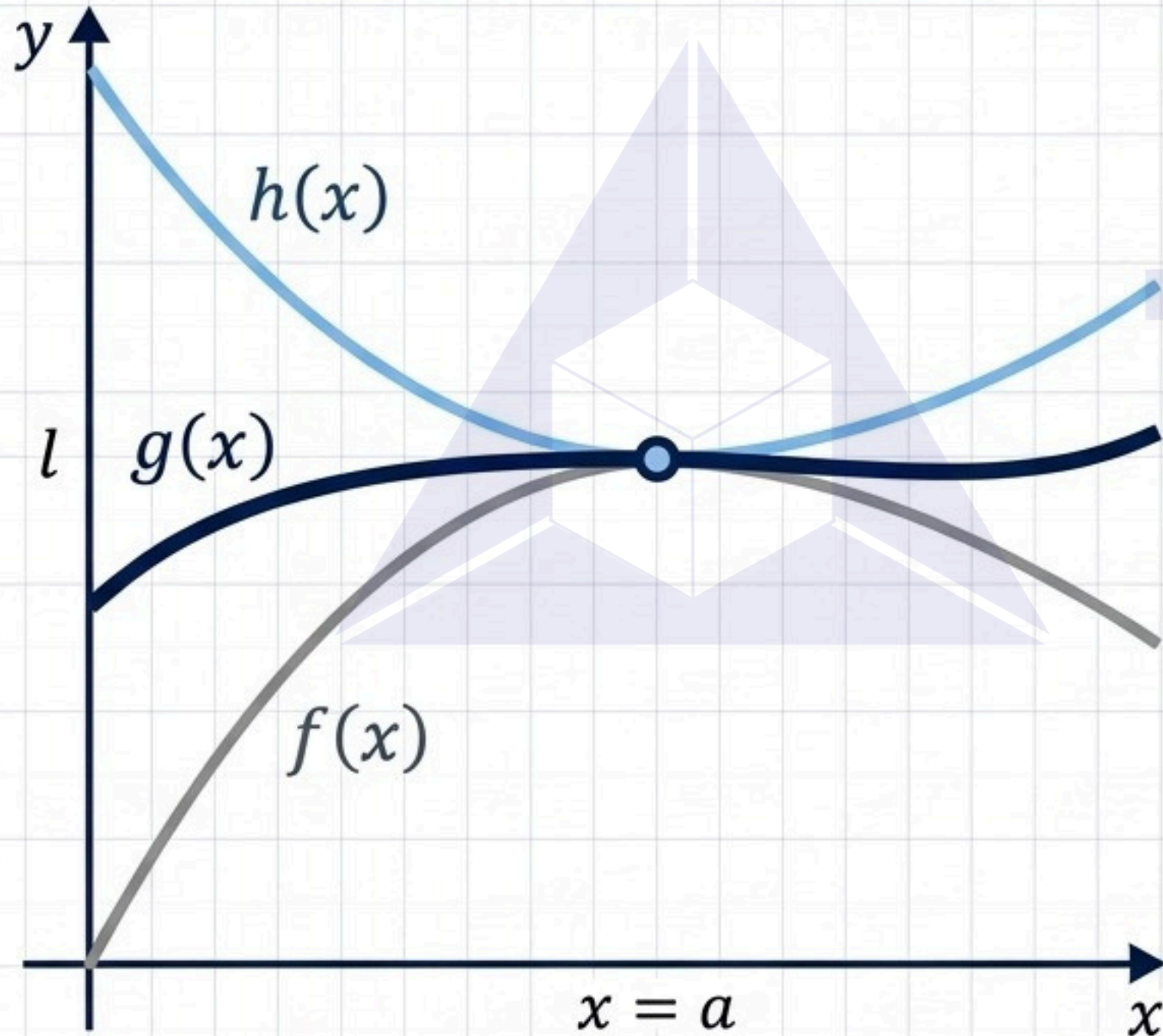
Standard Trigonometric Limits

Mastering Chapter 12.4 for
JEE Mathematics

The Logic Tool: The Sandwich Theorem



3-Layer Visual Squeeze



IF [Condition 1]

$$f(x) \leq g(x) \leq h(x)$$

(for all x in a common domain)

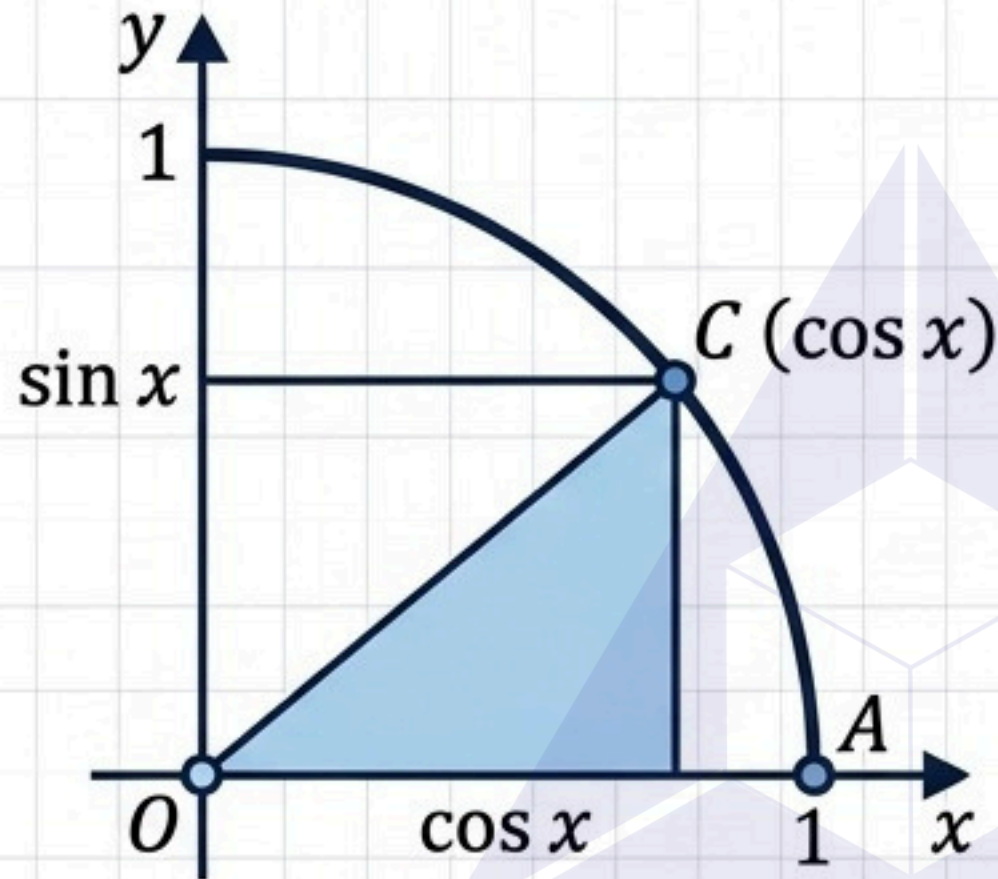
AND [Condition 2]

$$\lim_{x \rightarrow a} f(x) = l \text{ and } \lim_{x \rightarrow a} h(x) = l$$

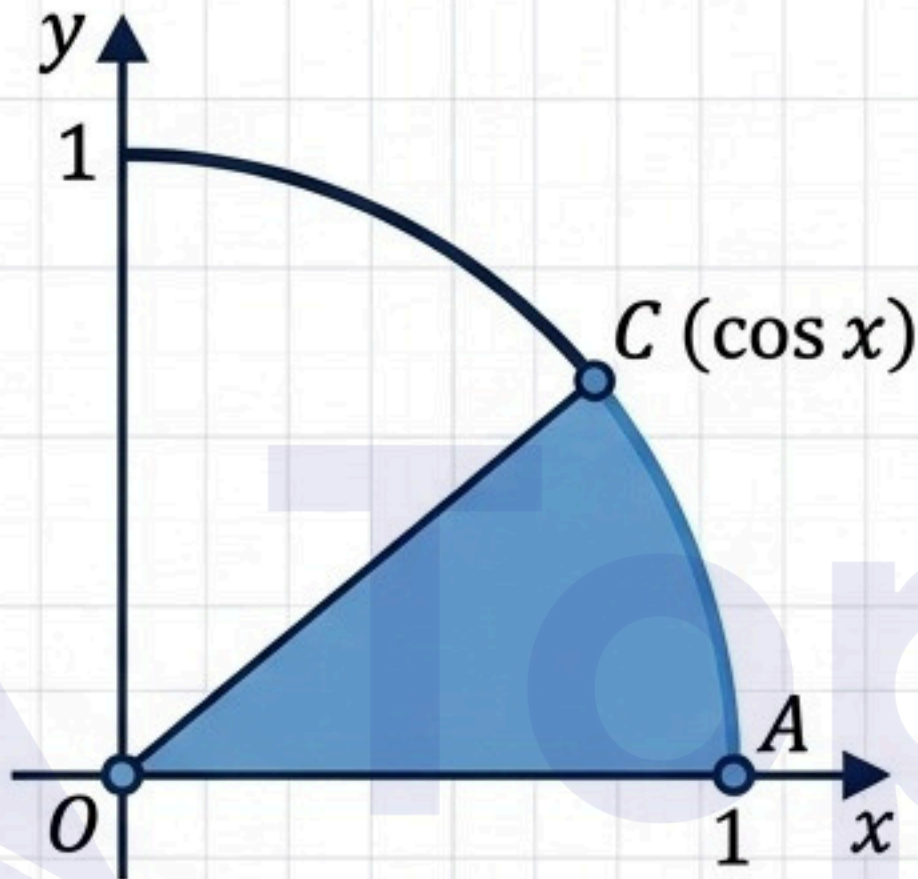
THEN [Conclusion]

$$\lim_{x \rightarrow a} g(x) = l$$

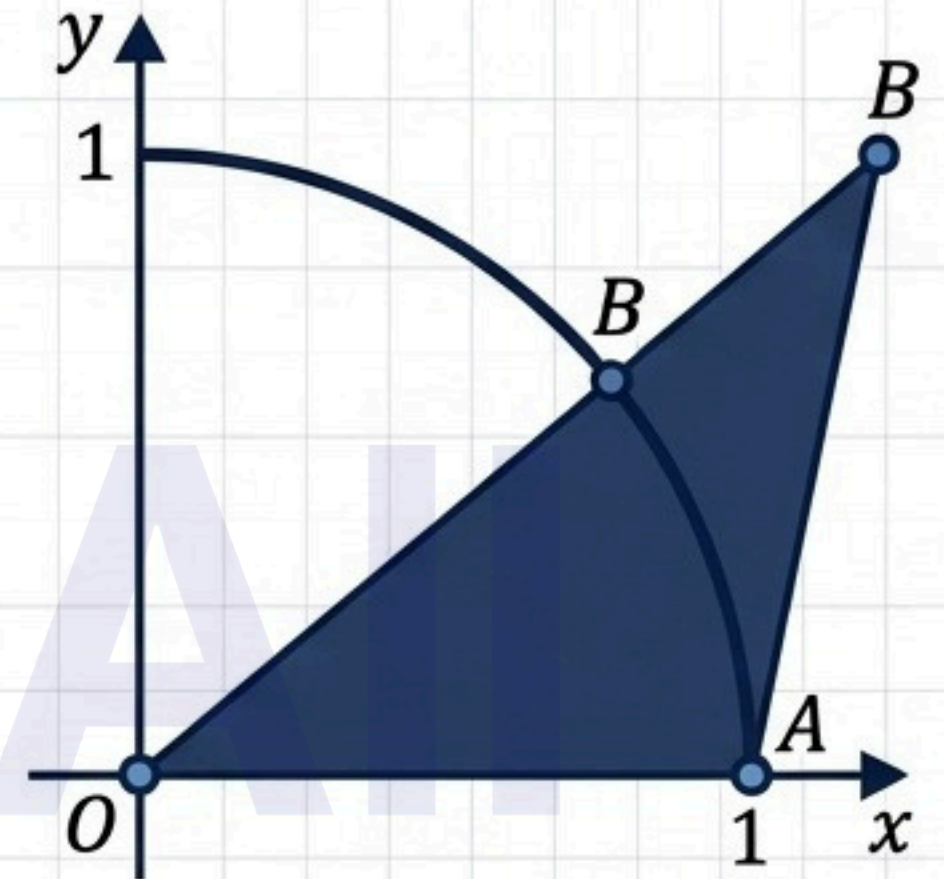
The Visual Proof: Unit Circle Inequality



$$\text{Area of } \triangle OAC = \frac{1}{2} \cdot 1 \cdot \sin x$$



$$\text{Area of Sector OAC} = \frac{1}{2} \cdot 1^2 \cdot x$$



$$\text{Area of } \triangle OAB = \frac{1}{2} \cdot 1 \cdot \tan x$$

By visually comparing the areas for $0 < x < \pi/2$, we instantly extract the core inequality: **$\sin x < x < \tan x$**



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The Arsenal: Standard Form Limits

Key Takeaways

$$\lim_{x \rightarrow 0} \frac{1 - \cos x}{x} = 0$$

$$\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1$$

$$\lim_{x \rightarrow 0} \frac{\tan x}{x} = 1$$

(All formulas rendered in strict monospace format. Valid explicitly when x approaches 0).

JEE Trap Alert: The Unit Assumption



Correct (Standard Form):

$$\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1$$

(Valid ONLY when x is in Radians)

The Trap (Degrees):

$$\lim_{x \rightarrow 0} \frac{\sin x^\circ}{x} \neq 1$$

The Fix: Convert degrees to radians first!

$$\sin x^\circ = \sin\left(\frac{\pi x}{180}\right).$$

Therefore, the true limit is $\frac{\pi}{180}$.

Mini Application: The Balancing Act

The Problem

$$\lim_{x \rightarrow 0} \frac{\sin 4x}{\sin 2x}$$

The Execution

Step 1: Isolate terms.

$$\frac{\sin 4x}{1} \cdot \frac{1}{\sin 2x}$$



Step 2: Multiply/Divide to create matching "boxes".

$$\left[\frac{\sin 4x}{4x} \cdot 4x \right] \cdot \left[\frac{2x}{\sin 2x} \cdot \frac{1}{2x} \right]$$



Step 3: Apply standard limit $\rightarrow 1$. Result:

$$\frac{4x}{2x} = 2$$

The Reshaping Protocol

Step 1 (Check State)

Verify $x \rightarrow 0$. If not, use substitution (e.g., $y = x - a$) to force the limit to 0.

Step 2 (Target the Box)

Identify the exact angle argument inside the trig function:
 $\sin(\text{box})$.

Step 3 (Balance & Execute)

Multiply and divide by the exact "box" value to artificially construct the $\sin(\text{box})/\text{box}$ form.

If you can build the box, the limit collapses to 1.



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