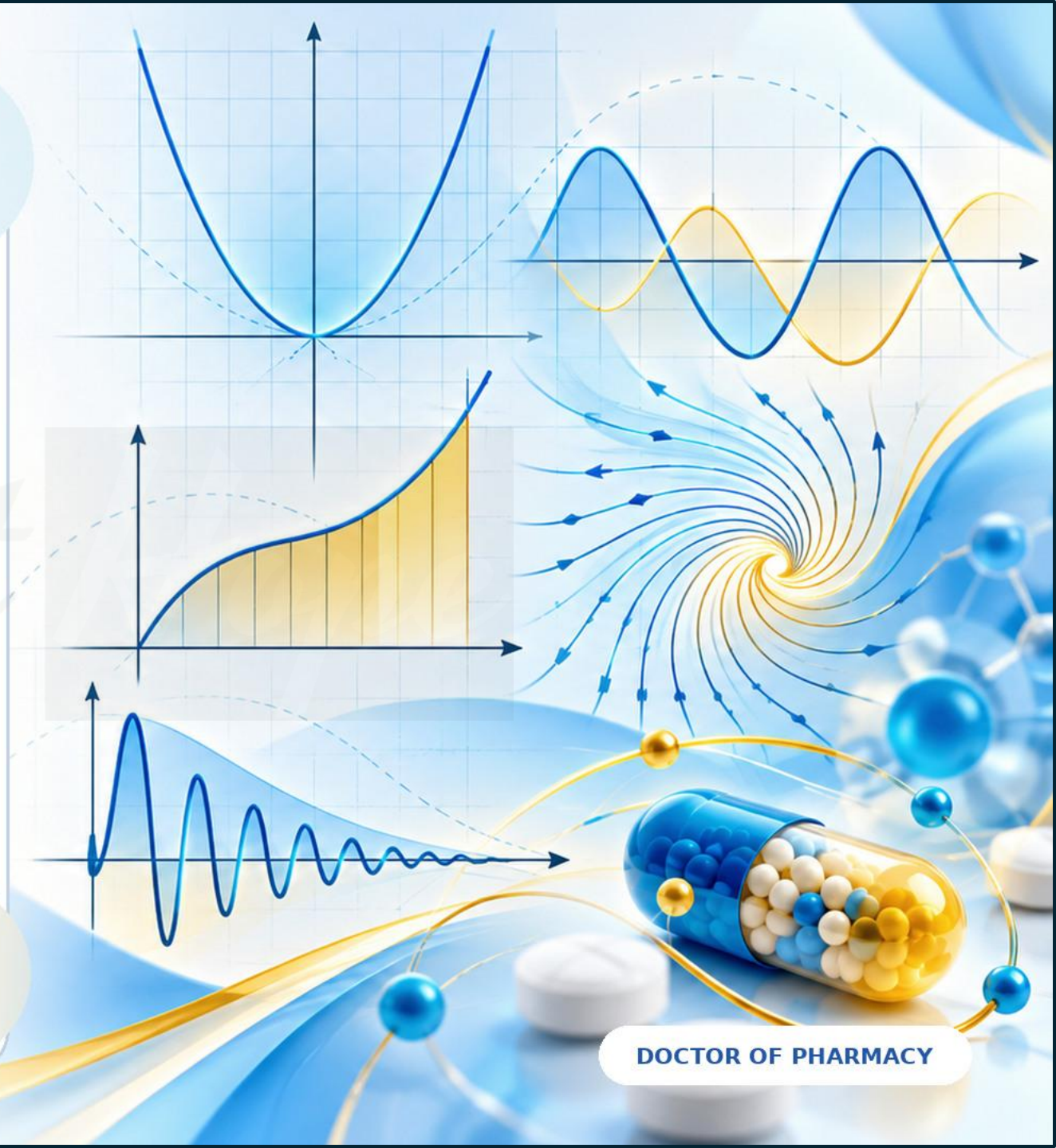
PHARM.D • YEAR 1

Remedial Mathematics

CHAPTER 4

Differential Calculus

PPT CHAPTER COVER



DOCTOR OF PHARMACY

Limits: the value approached

$$\lim_{x \to a} f(x) = L$$

The values of $f(x)$ approach L as x approaches a.

x need not equal a; $f(a)$ may even be undefined.

Precise Meaning

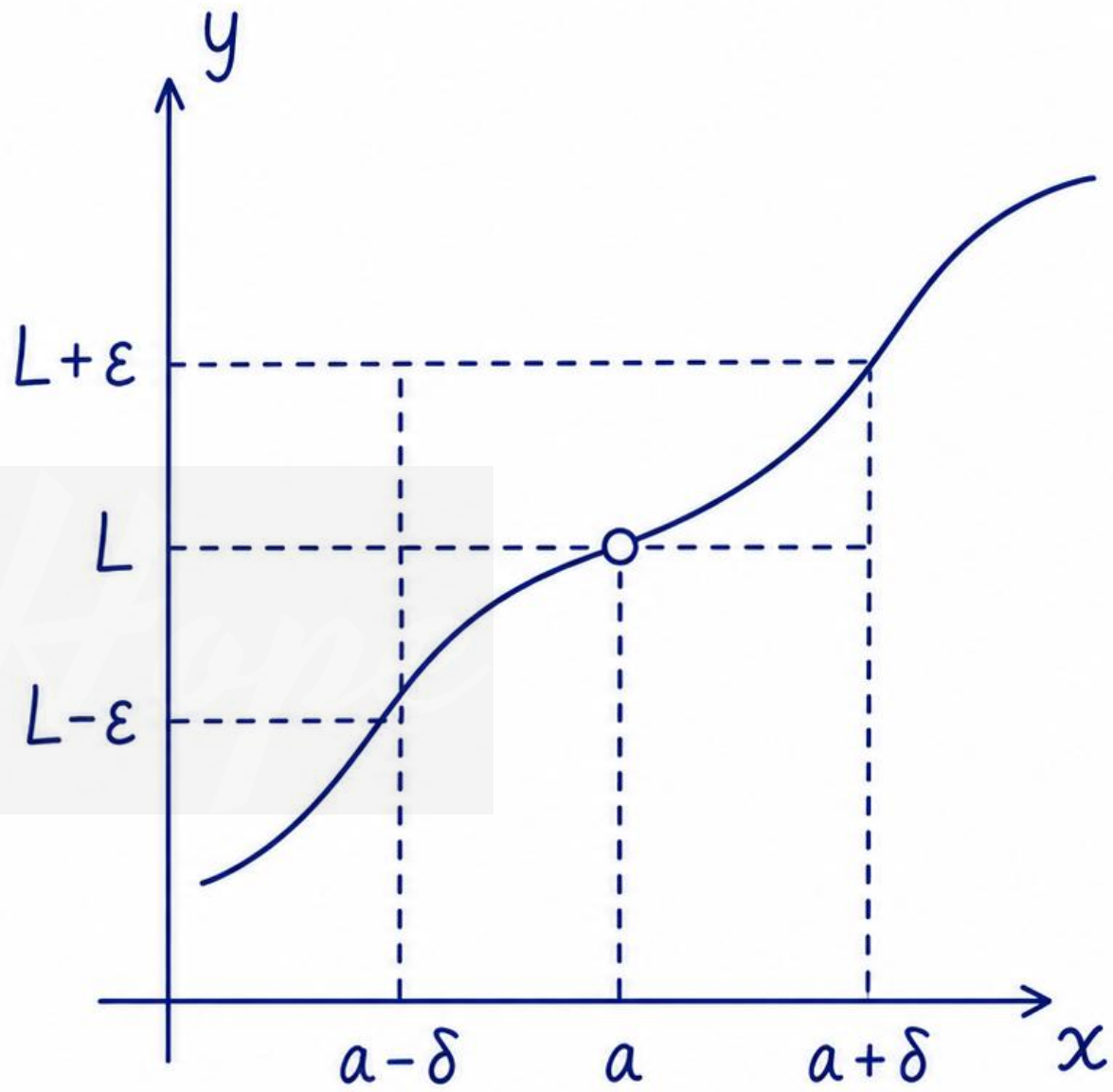
For every $\varepsilon > 0$, there is a $\delta > 0$ such that:

$$0 < |x - a| < \delta \Rightarrow |f(x) - L| < \varepsilon.$$

ε controls the allowed output error.

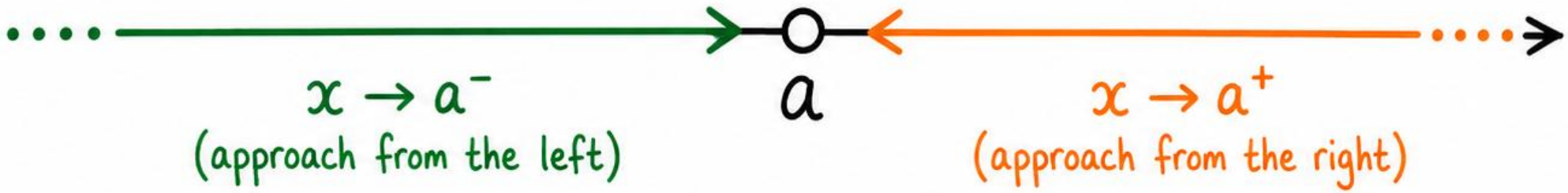
δ controls how close the input must be.

A limit describes nearby behaviour, not just substitution.



One-sided and infinite limits

- Left-hand limit: $x \to a^-$.
- Right-hand limit: $x \to a^+$.
- A two-sided finite limit exists only when both one-sided limits agree.
- If they differ, the two-sided limit does not exist.
- $f(x) \to +\infty$ means unbounded growth, not a finite limit.
- $x \to \infty$ studies behaviour far along the x-axis.
- Do not confuse $x \to a$ with $x \to \infty$.
- Always state which variable is approaching what.



Limit laws

$\lim_{x \to a} f(x) = L$ as $x \to a$

at the same point a

$\lim_{x \to a} g(x) = M$ as $x \to a$

If $\lim_{x \to a} f(x) = L$ and $\lim_{x \to a} g(x) = M$ at the same point:

- $\lim_{x \to a} (f + g) = L + M$
- $\lim_{x \to a} (f - g) = L - M$
- $\lim_{x \to a} (fg) = LM$
- $\lim_{x \to a} (kf) = kL$
- $\lim_{x \to a} \left(\frac{f}{g}\right) = \frac{L}{M}$, provided $M \neq 0$.

- For polynomials, direct substitution gives finite-point limits.
- For rational functions, substitution works when the denominator is non-zero.
- Check the denominator before using the quotient law.

Indeterminate forms: simplify first

$0/0$ is an indeterminate form, not an answer.

EXAMPLE

$$\lim_{x \to 1} \frac{x^2 - 1}{x - 1}$$

$$= \lim_{x \to 1} \frac{(x-1)(x+1)}{(x-1)}$$

← Cancellation is valid for $x \neq 1$, as required near the limit.

$$= \lim_{x \to 1} (x+1) = 2$$

Other indeterminate forms include $\frac{\infty}{\infty}$, $0 \cdot \infty$, $\infty - \infty$, 0^0, ∞^0 and 1^∞.

Use a justified method; L'Hôpital's rule requires its own hypotheses.

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