

Math 121 - Summary of Limit Laws

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Limit Laws

Assumptions

In the following, suppose:

- c represents a constant (a fixed number)

- The limits

$$\lim_{x \rightarrow a} f(x) \quad \text{and} \quad \lim_{x \rightarrow a} g(x)$$

both exist

- $\lim_{x \rightarrow a} [f(x) + g(x)] = \lim_{x \rightarrow a} f(x) + \lim_{x \rightarrow a} g(x)$
- In words: *The limit of a sum is the sum of the limits*

Difference Law

- $\lim_{x \rightarrow a} [f(x) - g(x)] = \lim_{x \rightarrow a} f(x) - \lim_{x \rightarrow a} g(x)$
- In words: *The limit of a difference is the difference of the limits*

Constant Multiplier Law

- $\lim_{x \rightarrow a} [cf(x)] = c \lim_{x \rightarrow a} f(x)$
- In words: *The limit of a constant times a function is the constant times the limit of the function.*

- $\lim_{x \rightarrow a} [f(x)g(x)] = \left(\lim_{x \rightarrow a} f(x) \right) \left(\lim_{x \rightarrow a} g(x) \right)$
- In words: *The limit of a product is the product of the limits*

Quotient Law

- $\lim_{x \rightarrow a} \left[\frac{f(x)}{g(x)} \right] = \frac{\lim_{x \rightarrow a} f(x)}{\lim_{x \rightarrow a} g(x)}$ provided $\lim_{x \rightarrow a} g(x) \neq 0$.

- In words: *The limit of a quotient is the quotient of the limits*

- $\lim_{x \rightarrow a} [f(x)]^n = \left[\lim_{x \rightarrow a} f(x) \right]^n$ where n is a positive integer.
- In words: *The limit of a power is the power of the limit*

- $\lim_{x \rightarrow a} \sqrt[n]{f(x)} = \sqrt[n]{\lim_{x \rightarrow a} f(x)}$ where n is a positive integer, and where $\lim_{x \rightarrow a} f(x) > 0$ if n is even.
- In words: *The limit of a root is the root of the limit*

Particular Limit Results

Constants

- $\lim_{x \rightarrow a} c = c$

- Example: $\lim_{x \rightarrow 3} \sqrt{2\pi} = \sqrt{2\pi}$

Limit of $f(x) = x$

- $\lim_{x \rightarrow a} x = a$

- Example: $\lim_{x \rightarrow 5} x = 5$

- Using the Sum, Difference, Constant Multiplier and Power Laws:

If $f(x)$ is a polynomial, (for eg. $f(x) = 5x^3 - \pi x^2 - \frac{1}{2}$), then
 $\lim_{x \rightarrow a} f(x) = f(a)$.

- Example:

$$\lim_{x \rightarrow -1} 5x^3 - \pi x^2 - \frac{1}{2} = 5(-1)^3 - \pi(-1)^2 - \frac{1}{2} = -\pi - \frac{11}{2}$$

- Using the previous result and the Quotient Law:

If $f(x)$ and $g(x)$ are polynomials and $g(a) \neq 0$ then

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

- Example: $\lim_{x \rightarrow 2} \frac{2x^3 - x}{3x + 1} = \frac{2(2)^3 - (2)}{3(2) + 1} = \frac{14}{7} = 2$