

Calculus

1. Limits

Definition: A function $f(x)$ has a limit L as x approaches a if for every $\epsilon > 0$, there exists a $\delta > 0$ such that $0 < |x - a| < \delta$ implies $|f(x) - L| < \epsilon$.

Example: $\lim_{x \rightarrow 2} (3x - 1) = 5$. For $\epsilon = 1$, choose $\delta = 1/3$. Then $0 < |x - 2| < 1/3$ implies $|3x - 1 - 5| = |3x - 6| = 3|x - 2| < 3 \cdot 1/3 = 1$.

Example: $\lim_{x \rightarrow 0} \sin(x) = 0$. For $\epsilon = 1/2$, choose $\delta = 1/2$. Then $0 < |x| < 1/2$ implies $|\sin(x)| < 1/2$.

Example: $\lim_{x \rightarrow 0} \frac{\sin(x)}{x} = 1$. For $\epsilon = 1/2$, choose $\delta = 1/2$. Then $0 < |x| < 1/2$ implies $|\frac{\sin(x)}{x} - 1| < 1/2$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x}| > 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x^2} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^2}| > 1$.

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Example: $\lim_{x \rightarrow 0} \frac{1}{x^4} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^4}| > 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x^5} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^5}| > 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x^6} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^6}| > 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x^7} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^7}| > 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x^8} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^8}| > 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x^9} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^9}| > 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x^{10}} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^{10}}| > 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x^{11}} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|\frac{1}{x^{11}}| > 1$.

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