



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: $\lim_{x \rightarrow 2} (x^2 - 4) = 0$. For $\epsilon = 1$, choose $\delta = 1$. Then $0 < |x - 2| < 1$ implies $|x^2 - 4| < 1$.

Example: $\lim_{x \rightarrow 0} \frac{1}{x}$ does not exist.

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

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

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

Example: $\lim_{x \rightarrow 0} e^x = 1$. For $\epsilon = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $|e^x - 1| < 1$.

Example: $\lim_{x \rightarrow 0} \ln(x)$ does not exist.

Example: $\lim_{x \rightarrow \infty} \ln(x)$ does not exist.

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

Example: $\lim_{x \rightarrow 0} \frac{1}{x^3} = \infty$. For $M = 1$, choose $\delta = 1$. Then $0 < |x| < 1$ implies $\frac{1}{x^3} > 1$.

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 $\frac{1}{x^{10}} > 1$.

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