L'hôpital's Rule Encyclopedia Article

L'hôpital's Rule

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L'hôpital's Rule

L'Hôpital's rule provides an efficient technique for using derivatives to evaluate **limits** of quotients of **functions** that can otherwise not be determined. It uses derivatives to find limits of functions and different forms can be applied to the two main types of indeterminate forms: / and 0/0.

L'Hôpital's rule is usually written as follows: Let *f* and *g* be continuous functions defined on an **interval** [*a, b*] and differentiable on (*a, b*). Suppose that *g'(x)* 0 for $a < x < b$ and $\lim_{xa+} f(x) = \lim_{xa+} g(x) = 0$. Then if $\lim_{xa+} f'(x)/g'(x)$ exists, and $\lim_{xa+} f(x)/g(x)$ also exists and the two are equal: $\lim_{xa+} f'(x)/g'(x) = \lim_{xa+} f(x)/g(x)$. This is also true if $\lim_{xa+}$ is replaced by $\lim_{xb-}$, or by $\lim_{xc}$ where *c* is any number in [*a, b*]. In the case where $\lim_{xc}$ *f* and *g* need not be differentiable at *c*.

L'Hôpital's rule can be applied to many different situations. It can be applied to the two types of indeterminate forms, 0/0 and /. These forms arise when $\lim_{xa+} f(x) = 0 = \lim_{xa+} g(x)$. Then it is said that $\lim_{xa+} f(x)/g(x)$ has the indeterminate form 0/0 because the limit may or may not exist. The same idea applies if $\lim_{xa+}$ is replaced by $\lim_{xb-}$, $\lim_{xc}$, $\lim_{x}$, or $\lim_{x-}$. L'Hôpital's rule can also be applied to the following situations: $\lim f(x)*g(x)$, where *f(x)* approaches **infinity** and *g(x)* approaches **zero**; $\lim f(x)-g(x)$, where both *f(x)* and *g(x)* approach infinity; $\lim f(x)^{g(x)}$, where both *f(x)* and *g(x)* approach infinity; $\lim f(x)^{g(x)}$, where *f(x)* approaches infinity and *g(x)* approaches zero; and $\lim f(x)^{g(x)}$, where *f(x)* approaches one and *g(x)* approaches infinity.

French mathematician Marquis Guillaume F. A. de l'Hôpital is attributed with formulating l'Hôpital's rule. The rule first formally appeared in l'Hôpital's book *analyse des infiniment petits pour l'intelligence des lignes courbes* published in 1696 and is the first text book concerned with differential **calculus**. Although the rule first appeared here it should really be called Bernoulli's rule because it first appears in a letter from **Johann Bernoulli** to l'Hôptal in 1694. L'Hôpital and Bernoulli had made an agreement under which l'Hôpital paid Bernoulli a monthly fee for solutions to particular problems. It was in one of these correspondences that the rule was first formulated. L'Hôpital's first use was in connection to solving: $\lim_{xa} [(2a^3x-x^4) -a^3(a^3x)]/[a - {}^4(ax^3)]$. The generalized **mean** value **theorem** plays an important role in proving l'Hôpital's rule.