Calculus basics

Slope of a Tangent line to f(x) at x = a:

Method 1: $$f'(a) = \lim_{h \to 0} \frac{f(a+h) - f(a)}{h}$$

Method 2: $$f'(a) = \lim_{x \to a} \frac{f(x) - f(a)}{x-a}$$

Using Limit to find the ***Derivative*** *of a function f(x):*

$$\frac{d}{dx} f(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

Tangent Line formula at a given point; P(a, f(a)):

$$y = f'(a)(x - a) + f(a)$$

Multifactor derivative:

Product Rule: $y = u.v$ $\quad$ $y' = u'.v + v'.u$

$y = u.v.w$ $\quad$ $y' = u'.v.w + v'.u.w + w'.u.v$

Quotient Rule: $y = \frac{u}{v}$ $\quad$ $y' = \frac{u'v - v'u}{v^2}$

Composite Functions derivative, ***Chain Rule****:*

$y = f(g(h(x))) = f \circ g \circ h(x)$ $\quad$ *Therefor:* $\quad$ $y' = f'(g(x))g'(x)$ $\quad$ *or simply:* $y' = f'.g'.h'$

Absolute Value derivative*: Consider that:* $|x| = \sqrt{x^2}$

$$\frac{d}{dx}|u| = \frac{d}{dx}\sqrt{u^2}\frac{d}{dx}|u| = \frac{2uu\prime}{2\sqrt{u^2}} = \frac{uu\prime}{|u|}$$

Inverse function derivative:

$$\frac{d}{dx}\left(f^{-1}(x)\right) = \left(f^{-1}(x)\right)' = \frac{1}{f'\left(f^{-1}(x)\right)}$$

Note: $f\left(f^{-1}(x)\right) = x$ $\quad$ *and;* $\quad$ $f^{-1}\left(f(x)\right) = x$

Newton's Method*, to calculate approximate root of a function:*

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

Input x_0, close to the expected root, then, find x_1. Use this number to find x_2 and keep doing, until the value does not change within the desired accuracy.

info@e-tutorpro.com Phone: 1 604 710-9602

***Exponential growth*:**

$$P = P_0 e^{kt}$$

Growth Rate:

$$\frac{dP}{dt} = kP_0 e^{kt} = kP$$

Newton Law of cooling:

If the exponential growth/decay function approaches to a limit not zero:

Cooling objects: cools down from T_{0}, to the room temperature T_s:

Assume: $y = T - T_s$, *and* $y_0 = T_0 - T_s$

$$y = y_0 e^{kt} \qquad T - T_s = (T_0 - T_s)e^{kT}$$

$$y'(t) = T'(t) = ky \qquad Therefor: \qquad \frac{dT}{dt} = k(T - T_s)$$

L'Hopital's Rule:

$$\lim_{x\to 0} \frac{f(x)}{g(x)} = \lim_{x\to 0} \frac{f'(x)}{g'(x)} \qquad g(x) \neq 0$$

Power Series: *natural number power:*

$$\sum_{i=1}^{n} i = \frac{n(n+1)}{2}$$

$$\sum_{i=1}^{n} i^2 = \frac{n(n+1)(2n+1)}{6}$$

$$\sum_{i=1}^{n} i^3 = \frac{n^2(n+1)^2}{4}$$

$$\sum_{i=1}^{n} i^4 = \frac{n(n+1)(6n^3+9n^2+n-1)}{30}$$

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