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Basic theorems of differential calculus and their application

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Annotation. This article gives you some easy ways to solve common. Basic theorems of differential calculus and their application

Key words: vector, inequality, angle, identity

We can often use theorems on derivative functions to solve some problems. These theorems play an important role in checking functions.

Theorem 1 (Farm theorem).

$f(x)$ function $X \subset R$ given in the package. $x_0 \in X$ for the circumference of the point $U_\delta(x_0) = (x_0 - \delta,\ x_0 + \delta) \subset X \quad (\delta > 0)$ The following conditions must be met:

1) $\forall x \in U_\delta(x_0)$ da $f(x) \le f(x_0) \qquad (f(x) \ge f(x_0))$,

2) $f'(x_0)$

be available and limited.

Then $f'(x_0) = 0$ is being..

Let's say, $\forall x \in U_\delta(x_0)$ in $f(x) \le f(x_0)$ let it beObviously, in this case

$$f(x) - f(x_0) \le 0$$

will be.Conditionally $f(x)$ function x_0 limited in point $f'(x_0)$ yield.Then

$$f'(x_0) = \lim_{x \to x_0} \frac{f(x) - f(x_0)}{x - x_0} = \lim_{x \to x_0 + 0} \frac{f(x) - f(x_0)}{x - x_0} = \lim_{x \to x_0 - 0} \frac{f(x) - f(x_0)}{x - x_0}$$

Will be.At the moment , $x > x_0$ will be

$$\frac{f(x) - f(x_0)}{x - x_0} \le 0 \quad \Rightarrow \quad \lim_{x \to x_0 + 0} \frac{f(x) - f(x_0)}{x - x_0} = f'(x_0) \le 0,$$

$x < x_0$ will be

$$\frac{f(x) - f(x_0)}{x - x_0} \ge 0 \quad \Rightarrow \quad \lim_{x \to x_0 - 0} \frac{f(x) - f(x_0)}{x - x_0} = f'(x_0) \ge 0 \text{ from } f'(x_0) = 0 \text{ It}$$

turns out that.

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Theorem 2 (Roll theorem).Suppose, $f(x)$ function $[a, b]$to meet the following conditions:

1) $f(x) \in C[a, b]$,

2) $\forall x \in (a, b)$in $f'(x)$available and limited,

3) $f(a) = f(b)$let it be. $x_0 \in (a, b)$ $f'(x_0) = 0$

Conditionally $f(x) \in C[a, b]$. According to Weierstrass's second theorem $f(x)$ function $[a, b]$at its maximum and minimum values, c_1, c_2 points $(c_1, c_2 \in [a, b])$ found,

$$f(c_1) = \max\{ f(x) \mid x \in [a, b]\},$$
$$f(c_2) = \min\{ f(x) \mid x \in [a, b]\}$$

Has been.

If $f(c_1) = f(c_2)$ been, Then $[a, b]$ in $f(x) = const$ is being, $\forall x_0 \in (a, b)$at $f'(x_0) = 0$.

If $f(c_1) > f(c_2)$ be, thats $f(a) = f(b)$because $f(x)$ function $f(c_1)$ and $f(c_2)$to at least one of the values $[a, b]$the interior of the segment x_0 $(a < x_0 < b)$ .reach the point According to the farm theorem $f'(x_0) = 0$will be. ▶

3-theorem (Lagranj by theorem).Suppose, $f(x)$ function $[a, b]$ at will be,fulfill the following conditions:

1) $f(x) \in C[a, b]$,

2) $\forall x \in (a, b)$at $f'(x)$the product is available and limitedIn that case it is so $c \in (a, b)$poind found ,

$$f(b) - f(a) = f'(c)(b-a)$$

will be.

This $F(x) = f(x) - f(a) - \frac{f(b) - f(a)}{b-a}(x-a)$ (1)

Let's look at the function. This function satisfies all the conditions of the Roll theorem. At the same time, its a product

$$F'(x) = f'(x) - \frac{f(b) - f(a)}{b-a}$$

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will be.According to the roll theorem, so c $(c \in (a,\ b))$ the point is found,

$$F'(c) = 0 \qquad (2)$$

Will be.

(1) and (2) from equations

$$f'(c) - \frac{f(b) - f(a)}{b - a} = 0, \text{that is } f(b) - f(a) = f'(c)(b - a)$$

will occur.

1-result. Let's say, $f(x)$ function $(a,\ b)$ at $f'(x)$,having a product $\forall x \in (a,\ b)$ at $f'(x) = 0$ being to. Then $\forall x \in (a,\ b)$ at $f(x) = const$ will be.

$x,\ x_0 \in (a,\ b)$ take, edges x and x_0 in the segment $f(x)$ using Lagrange's theorem on the function $f(x) = f(x_0) = const$ being found. ▶

2-result. $f(x)$ and $g(x)$ function $(a,\ b)$ at $f'(x)$, $g'(x)$,products $\forall x \in (a,\ b)$ in $f'(x) = g'(x)$ been. Then $\forall x \in (a,\ b)$ in $f(x) = g(x) + const$ will be.

This is proof of the result $f(x) - g(x)$ by applying result 1 to the function.Theorem 4 (Cauchy Theorem). Let, and let the functions fulfill the following conditions.

1) $f(x) \in C[a,\ b],\ g(x) \in C[a,\ b]$,

2) $\forall x \in (a,\ b)$ da $f'(x)$ va $g'(x)$ crops are available and limited;

3) $\forall x \in (a,\ b)$ da $g'(x) \neq 0$ will be.

Then $c \in (a,\ b)$,the point is found

$$\frac{f(b) - f(a)}{g(b) - g(a)} = \frac{f'(c)}{g'(c)}$$

Willbe.

First of all $g(b) \neq g(a)$ We emphasize that because $g(b) = g(a)$ if so, then according to Roll's theorem $c \in (a,\ b)$ the point would be found $g'(c) = 0$ would be This is contrary to condition

3) The following

$$\Phi(x) = f(x) - f(a) - \frac{f(b) - f(a)}{g(b) - g(a)}[g(x) - g(a)] \quad (x \in [a,\ b])$$

$c \in (a,\ b)$ found point ,

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$\Phi'(c)=0$ will be (3)

$$\Phi'(x)=f'(x)-\frac{f(b)-f(a)}{g(b)-g(a)}g'(x) \quad (4)$$

Obviouly,

(3) and (4) relationship

$$f'(c)-\frac{f(b)-f(a)}{g(b)-g(a)}g'(c)=0$$

that is $\frac{f(b)-f(a)}{g(b)-g(a)}=\frac{f'(c)}{g'(c)}$

will occur.

Example 1. $\forall x',\ x''\in R$ for $|\sin x'-\sin x''|\le|x'-x''|$ prove the inequality.

Let's say, $x'<x''$ will be. $f(x)=\sin x$ in $[x',\ x'']$ We apply Lagrange's theorem.That's it $c\in(x',\ x'')$ the point is that,

$$|\sin x'-\sin x''|=|\cos c|\cdot(x''-x')$$

willbe.If $\forall t\in R$ at $|\cos t|\le 1$ Given that, then from the above relationship,

$$|\sin x'-\sin x''|\le|x'-x''| \qquad (\forall x',\ x''\in R)$$

Being.

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