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DERIVATIVE OF A FUNCTION AND ITS APPLICATIONS THROUGH THE MAPLE SOFTWARE PACKAGE

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Abstract
This article analyzes the process of teaching the derivative of a function and its applications using the Maple software package. The differential calculus section of mathematical analysis not only provides students with fundamental knowledge, but also allows for a deeper understanding of concepts through practical programming tools. Using the Maple software package to compute derivatives of functions and to represent their geometric interpretations graphically helps students gain a clearer understanding. The capabilities of the Maple software in differentiating functions, calculating derivatives, and visualizing results are discussed. The results of the study show that teaching with the Maple package enhances the practical reinforcement of theoretical knowledge, facilitates comprehension through visualization, and develops independent working skills. Therefore, the Maple software package plays a significant role in teaching mathematical analysis in modern education.

Keywords: Function derivative, function differentiation, operator, Maple, differential calculus, mathematical modeling, graphical visualization, mathematics education, physics, economics, biology, ecology, code.

FUNKSIYANING HOSILASI VA UNING TADBIQLARINI MAPLE DASTURLAR PAKETI YORDAMIDA O'QITISH

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Annotatsiya Ushbu maqolada funksiya hosilasi va uning tadbiqlari Maple dasturlar paket yordamida o'qitish jarayoni tahlil qilinadi. Matematik analizning differensial hisob bo'limi talabalarga fundamental bilim berish bilan birga, amaliy dasturlash vositalari yordamida tushunchalarni chuqurroq anglash imkonini ham yaratadi. Maple dasturlar paketi orqali funksiya hosilasini hisoblash va uning geometrik talqinini grafik usulda ifodalash o'quvchilarga yanada aniq tushuncha hosil qilishga yordam beradi. Maple dasturlar paket dasturining funksiyalarni differensiallash, hosilasini hisoblash va vizuallashirish imkoniyatlari ko'rib chiqiladi. Tadqiqot natijalari shuni ko'rsatdiki, Maple dasturlar paketi yordamida o'qitish jarayoni nazariy bilimlarni amaliy jihatdan mustahkamlash, vizuallashtirish orqali tushunish va mustaqil ishlash ko'nikmalarini rivojlantirish imkonini beradi. Shu sababli, Maple dasturlar paketi zamonaviy ta'limda matematik analizni o'qitishda muhim o'rin tutadi.
Kalit so'zlar:funksiya hosilasi, funksiyani differensialash, operator, Maple , differensial hisob, matematik modellashtirish, grafik vizuallashtirish, matematik ta'lim, fizika, iqtisod, biologiya, ekologiya, kod.

Introduction

In the field of mathematics, the derivative of a function is one of the most important concepts. The derivative is a fundamental element of differential calculus and is widely used in physics, engineering, economics, and other fields. The main task of differential calculus is to find the derivative of a function and study its properties. The derivative of a function is one of the key tools for deeply understanding and analyzing any process of change.

With the development of mathematics and its practical applications, differential calculus as a science continues to expand. In particular, the use of differential equations and derivatives in scientific research and technological processes has become increasingly relevant. In engineering, derivatives are used to analyze velocity, acceleration, and dynamic systems, while in economics, they are employed to assess the impact of changing variables. Moreover, in the fields of

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artificial intelligence and machine learning, derivatives play a crucial role in optimization and gradient descent algorithms.

With the advancement of modern technologies, the use of computer programs in teaching mathematical concepts has become increasingly significant. In particular, the Maple software package enables the automation of mathematical computations, fast and accurate calculation of derivatives, and their graphical visualization. This software is not only effective for working with mathematical formulas, but also useful for solving practical problems. Using Maple allows students to gain a deep understanding of the theoretical foundations of derivatives and to apply them across various disciplines. The Maple program plays an essential role in facilitating the learning process of differential calculus and connecting it with real-life applications.

This article examines methods of teaching the calculation and application of function derivatives using the Maple software. During the study, various applications of derivatives—particularly in the fields of engineering and economics—are analyzed. Furthermore, the effectiveness of the Maple software in the educational process and its advantages are also discussed.

Methodology and Literature Review: Extensive literature has been studied on the role of mathematical analysis and the Maple software package in the educational process. The book *Calculus* by J. Stewart [21] thoroughly covers the theoretical foundations of differential calculus and provides detailed information about its practical applications. T.M. Apostol's *Mathematical Analysis* [22] explains the fundamental principles of mathematical analysis and is aimed at reinforcing the concepts of differentiation and derivatives.

In A. Abdurahmonov’s book *Foundations of Mathematical Analysis* [1], broad information is presented about differential calculus and its practical applications. The work *Modern Technologies in Mathematics Education* by M. Mirzaev and others [2] analyzes methods of teaching mathematical analysis using digital technologies. In addition, K. Tursunov’s book *Digital Technologies and Education* [3] provides essential insights into the integration of digital tools in the learning process and their effectiveness.

Moreover, numerous international studies have addressed the significance of the Maple software package in mathematics education. In particular, the research

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conducted by Brown et al. [25] explores the role of the Maple package in visualization and applied programming.

The Maple software package is a powerful tool capable of automating and visualizing mathematical computations. The following methods were used in the course of the study:

- Analytical computation of function derivatives;
- Visualization of derivatives through graphical representations;
- Exploring the applications of derivatives through practical problems;
- Applying derivatives to real-life processes using the Maple software package;
- Analyzing students' skills in working with the Maple software package.

Using the diff() operator in Maple, one can compute derivatives of various functions. For example:

```
diff(x^3 + 2*x + 5, x);
```

This code calculates the derivative of a cubic function.

In addition, the Maple software package can also be used to solve problems in physics and economics.

For example, to calculate the velocity of a body using acceleration:

```
v := diff(5*t^2 + 3*t + 2, t);
a := diff(v, t);
```

Here, v is the velocity of the object, and a is its acceleration. In economics, the Maple software package can be used to calculate the elasticity coefficient based on product demand and supply:

```
E := (diff(Q, P) * P) /Q;
```

In this formula, Q represents the quantity of demand for the product, P is the product price, and E is the elasticity coefficient.

In addition, differential calculus can also be applied in the fields of biology and ecology using the Maple software package.

For example, the following code can be used to calculate the growth rate of a plant population:

```
P := 100*exp(0,05*t);
```

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diff(P, t);

Here, *P* represents the population size, *t* is time, and *0.05* is the growth rate. Typically, calculating the derivative and differential of complex functions takes a significant amount of time and can present various difficulties. The Maple software package helps to overcome these challenges.

For example, let us consider the following examples related to the derivatives of complex functions:

1. Given $f(x)=\sin^3 2x-\cos^3 2x$ We calculate the derivative of the function:

> **Diff(sin(2*x)^3-cos(2*x)^3,x)= diff(sin(2*x)^3-cos(2*x)^3,x);**

$$\frac{d}{dx}\left(\sin(2x)^3-\cos(2x)^3\right)=6\sin(2x)^2\cos(2x)+6\cos(2x)^2\sin(2x)$$

we get the result in the form.

We will also see an example of higher-order derivatives.

2. The following $f(x)=e^x(x^2-1)$ це calculate the 24th derivative of the function.

> **Diff(exp(x)*(x^2-1),x$24)=diff(exp(x)*(x^2-1),x$24): collect(%,exp(x));**

$$\frac{d^{24}}{dx^{24}}\left(e^x\left(x^2-1\right)\right)=\left(x^2+48x+551\right)e^x$$

As you can see, calculating such derivatives takes a lot of time. Programs like Maple provide us with a great opportunity.

3. Now we will see examples of the application of the derivative of a function. In this process, we can determine the extremum points of a function and various properties of the function through its graph. Including **extrema(f,{cond},x,'s')** We can determine the extremum point of a function using the operator. Here, f is the function, x is the argument, and 's' is the coordinate of the variable.

$f(x)=arctgx-\ln(1+x^2)$ Let's find the extrema of the function.

>readlib(extrema):

extrema(arctan(x)-ln(1+x^2)/2,{},x,'x0');x0;

$$\left\{\frac{1}{4}\pi-\frac{1}{2}\ln(2)\right\}$$

$$\{\{x=1\}\}$$

It visually identifies the extrema of the function.

2. Let's graph the function.

$y=arctg(x^2)$ We will graph the function and study all its properties.

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In the first part of the program, the variable y is assigned $arctg(x^2)$ is downloading and checking the function y for continuity at integers. The result is a continuous function.

> ***restart: y:=arctan(x^2):***
iscont(y, x=-infinity..infinity);

$$true$$

The following sections of the program determine the asymptotes of a function.

> ***k1:=limit(y/x, x=-infinity);***

$$k1 := 0$$

> ***k2:=limit(y/x, x=+infinity);***

$$k2 := 0$$

> **b1:=limit(y-k1*x, x=-infinity);** >

$$b1 := \frac{1}{2}\pi$$

> **b2:=limit(y-k1*x, x=+infinity);**

$$b2 := \frac{1}{2}\pi$$

Since k1=k2 and b1=b2, it is known that there is one asymptote. The variable yh is assigned the value defined in the variable b1.

> **yh:=b1;**

$$yh := \frac{1}{2}\pi$$

Now we determine whether the function has extrema or not, and if so, the maximum and minimum values of the extrema.

> **extrema(y,{},x,'s');s;**

$$\{0\}$$

$$\{\{x = 0\}\}$$

> **ymax:=maximize(y,x); ymin:=minimize(y,x);**

$$ymax := \frac{1}{2}\pi$$

$$ymin := 0$$

In the last part of our program $y = arctg(x^2)$After all the properties of the function have been determined above, the steps for constructing the graph of the function are outlined. We can choose the color, font, and size of each text on the

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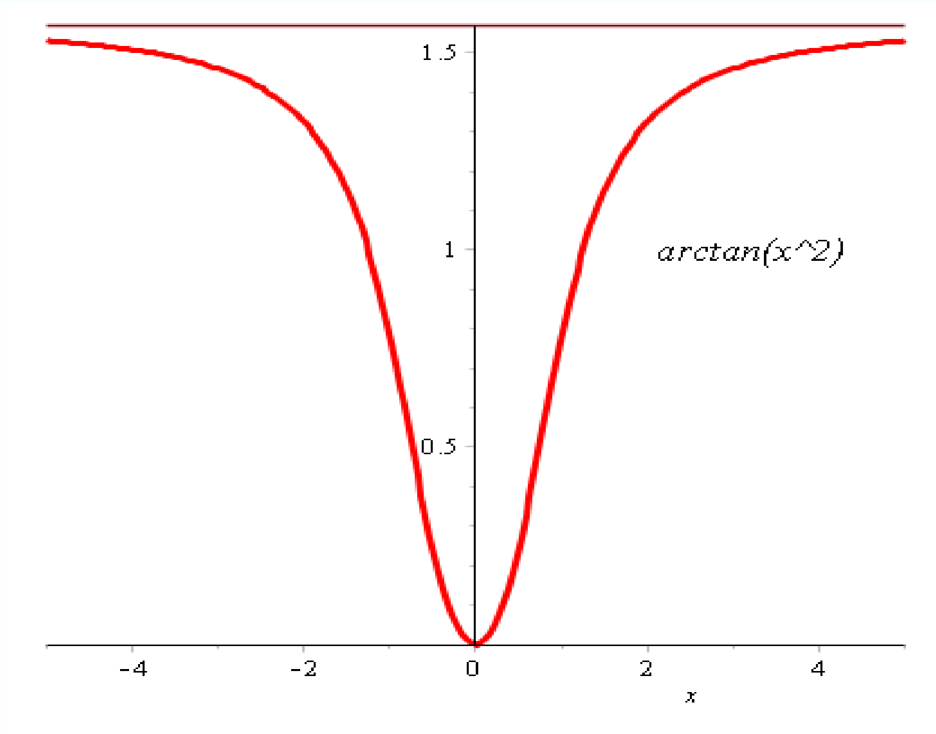
graph as we wish. $y = arctg(x^2)$ We can also show what interval the graph of a function should be drawn on. We can determine the interval according to the conditions of the problem.

> ***with(plots): yy:=convert(y,string):***
p1:=plot(y,x=-5..5, linestyle=1,hickness=3,color=RED):
p2:=plot(yh,x=-5..5, linestyle=1,thickness=1):
t1:=textplot([0.2,1.7,"ASIMPTOTA:"],
font=[TIMES, BOLD, 10], align=RIGHT):
t2:=textplot([3.1,1.7,"y=Pi/2"],
font=[TIMES, ITALIC, 10],align=RIGHT):
t3:=textplot([0.1,-0.2,"min:(0,0)"],align=RIGHT):
t4:=textplot([2,1,yy], font=[TIMES, ITALIC,14], align=RIGHT):
display([p1,p2,t1,t2,t3,t4]);



Note. All commands for graphing a function must be in a single open window of the Maple program, that is, in a single file.

Results It was found that the process of finding the derivative of a function using the Maple software package is much faster and more convenient than calculating it using conventional methods. Through graphical visualization, it became easier for students to understand the derivative. The results of the study showed the following aspects:

1. Finding the derivative using the Maple software package is accurate and efficient.
2. Depicting the derivatives of functions through graphs has a positive effect on students' understanding of the topic.
3. Explaining the importance of the derivative through practical examples and real-life problems increases students' interest.
4. Using the Maple software package, you can deeply study the application of differential calculus in technical and economic processes.
5. Using the derivative, you can determine the speed and acceleration of an object, solve economic analysis and optimization problems.
6. The program helps students develop skills in solving real-world problems based on differential calculus.
7. The interactive features of the Maple software package make it easier for students to work independently and consolidate their knowledge.

Discussion Based on the results of the study, it was found that the Maple software package is an important tool in studying differential calculus and the derivative of functions. Using this software package allows students not only to acquire theoretical knowledge, but also to apply it in solving real-life problems. In particular, graphic visualization and interactive modules make it easier for students to understand the subject. The advantages of the software package over other mathematical programs were also analyzed. Compared with programs such as MatLAB and Mathematica, it was found that the software package has a simple and convenient interface, is focused on mathematical calculations, and has wide capabilities in the field of differential calculus.

In addition, the role of the software package in the educational process should be expanded, and the methodological approaches it provides to teachers and the ability to support students' independent work should also be taken into account. Therefore, it is advisable to integrate the software package with modern pedagogical technologies.

Conclusion

Based on the results of the study, it was found that the software package is an effective tool for calculating the derivatives of functions and studying their applications in various fields. This program not only strengthens theoretical knowledge in the educational process, but also provides the opportunity to apply them in solving real problems. In particular, interactive tools and graphic visualizations facilitate understanding of the subject and increase the effectiveness of education. Also noteworthy are the convenience of the software package compared to other programs, the advantages of accelerating and ensuring the accuracy of differential calculation processes. In the future, it is necessary to introduce the software package more widely into the teaching process, integrate it with other subjects, and expand the opportunities for students to actively use it in the process of independent learning.

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