Application of Derivatives in Different Fields of Study

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Abstract— Derivative is the slope at a point on a line around the curve. It is a fundamental tool of calculus. It is basically the rate of change at which one quantity changes with respect to another. The derivative is called an Instantaneous rate of change that is, the ratio of the instant change in the dependent variable with respect to the independent variable. If f(x) is the function then the derivative of it will be represented by f'(x).

Keywords: Derivative, Physics

I. Introduction

Calculus was discovered by Isaac Newton and Gottfried Leibniz in 17th Century. But it was not possible without the early developments of Isaac Barrow about the derivatives in 16th century. Gottfried Wilhelm Leibniz introduced the symbols dx, dy, and $\frac{dx}{dy}$in 1675.This shows the functional relationship between dependent and independent variable.

Joseph Louis Lagrange introduced the prime notation f'(x).

These two are the commonly used notations. There are two more notations introduced by
Newton and Euler.
Newton's Notation $\dot{y}$
Euler's Notation $D_x f(x)$
What does it mean to differentiate a function in calculus?

Differentiation means to find the rate of change of a function or you can say that the process of finding a derivative is called differentiation.

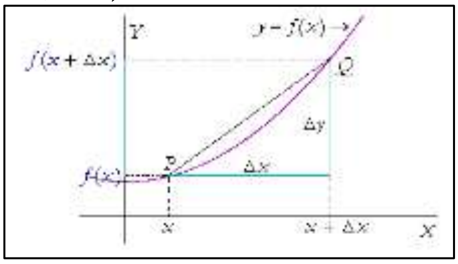
For Example

Speed tells us how fast the object is moving and that speed is the rate of change of distance covered with respect to time. So we can say that speed is the differentiation of distance with respect to time.

To differentiate a function, we need to find its derivative function using the formula.
Here x∈ (a, b) and f is differentiable on (a,b).
This can be represented graphically.

II. Graphical Representation of Derivatives

Studies have identified two students' misconceptions about the graphical representations of the derivative: assumptions that the graphs of a function and its derivative resemble each other, and the derivative of an increasing (decreasing) function is always positive (negative). Choi (2001) found that students are likely to assume that the graphs of a function and its derivative take the same direction, and thus the same sign of the slope resulting in the same shapes of graphs. In Nemirovsky and Rubin's (1992) study, when asked to graph the derivative function, many students drew a similar graph to the original function by matching overall characteristics of the two graphs. Nemirovsky and Rubin (1992) argued that this tendency was likely due to the plausibility of the physical contexts, if an object has positive increasing velocity, its distance also increases as time passes, and thus using examples from various situations can help understand this relationship better. Studies also found that students assume that an increasing (decreasing) function has a non-zero positive (negative) slope when they identify the interval where a function increases. They did not consider including the equal sign in the inequality, f'(x) > 0 due to their image that a function does not change near the points where f'(x) =0(Choi, 2001)



III. Origin of Application of Derivative

In Isaac Newton's day, one of the biggest problems was poor navigation at sea. • Before calculus was developed, the stars were vital for navigation. • Shipwrecks occurred because the ship was not where the captain thought it should be. There was not a good enough understanding of how the Earth, stars and planets moved with respect to each other. • Calculus (differentiation and integration) was developed to improve this understanding.

IV. Application of Derivative

There are countless areas where derivatives are used, but some of the most important are mathematical physics, biology and economics. We'll list some specific examples here. These will not be covered on the final, and they are simply designed to give you a taste of how calculus is used in the real world.

A. Biology

To model population growth, ecosystems, the spread of disease and various other phenomena. The area that we will focus on here is population growth. Q. Consider Patient Zero became infected on day 0, and each person per day gets infected afterward. This caused the population of infected to double every day. So, the population at time t was given by P(t) = 2^t (exponential function),where t is the no. of day. Finding rate of growth= P' (t) = (2^t) log2 i.e. a Differential equation (Though the above model cannot be stated ideal as we are not considering those who dies due to the infection thus a better model can be formed using differential equation that considers all the other points)

B. Physics

We've already seen some applications of derivatives to physics. In particular, we saw that the first derivative of a position function is the velocity, and the second derivative is acceleration.

C. Economics

In particular, we'll show how optimization (finding minimum and maximum values) can be useful in economics. Q. Consider we need to maximize profit. Suppose that p(x) is the price per unit that a company can charge to sell x units. The total revenue gained by selling this particular product is R(x) = xp(x) If we let C(x) denote the cost of manufacturing and selling x units, then the profit made by selling x units is P(x) = R(x)-C(x). To maximize this, we need to find the critical points of the function i.e. differentiate it….P'(x) so

1) If P'(x) PROFIT
2) If P'(x)>0 =>LOSS

Basically we use the derivative to determine the maximum and minimum values of particular functions (e.g. cost, strength, amount of material used in a building, profit, loss, etc.). Derivatives are met in many engineering and science problems, especially when modeling the behavior of moving objects.

V. OTHER USES OF DERIVATIVE

1) It is used in history, for predicting the life of a stone.
2) It is used in geography, which is used to study the gases present in the atmosphere.
3) It is mainly used by pilots to measure the pressure in the air and many more.

VI. CONCLUSION

There are many situations in engineering, where one may need to understand the relationship between two variables, more important, how a change in one variable affects other variable. To study change in a variable with respect to change in other variable, derivatives are used. A simple example is to study the change in velocity of an object with respective change in time; derivatives can be used to understand it with the help of equations as well as graphically.

Engineering involves rigorous and precise calculations and derivatives and integration do that.

At the same time are financial instruments that have values derived from other assets like stocks, bonds, or foreign exchange. Derivatives are sometimes used to hedge a position (protecting against the risk of an adverse move in an asset) or to speculate on future moves in the underlying instrument. Hedging is a form of risk management that is common in the stock market, where investors use derivatives called put options to protect shares or even entire portfolios.

So not only in study, derivative is equally important in our daily life.

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