Derivative - notation and interpretation

Intro

We know how to calculate the gradient function of certain functions.

For instance if the function is:

$$y = 2x^2 - \frac{3}{x}$$

then to calculate the gradient function we rewrite it into $y = 2x^2 - 3x^{-1}$ and then calculate the gradient function:

$$y' = 4x - 3(-1)x^{-2} = 4x + \frac{3}{x^2}$$

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Notation

We use $'$ to denote the derivative (gradient function). So for instance if we have $f(x)$, the derivative is $f'(x)$, if we have y, we use y' to denote the derivative. This notation is due to Lagrange and Newton.

There is another common way to denote derivatives (and is due to Leibniz) and it uses $\frac{d}{dx}$. So a derivative of $f(x)$ would be $\frac{df}{dx}$ and derivative of y would be $\frac{dy}{dx}$.

You can use either one, but you should know both as they may both appear on the exam.

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Example

Let $A(x) = 3x^2 - 4x + 1$. Find $\frac{dA}{dx}$.

The question simply asks to calculate the gradient function of $A(x)$:

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Recall that the derivative (gradient function) simply tells what is the gradient of a given function at a certain point. For linear functions the gradient is constant, but for other functions the gradient changes as x changes.

So the derivative tells you what is the instantaneous **rate of change** of a given function. Consider the example of travelling from Warsaw to Krakow by car.

If at a some point in time the speedometer in your car shows $80\frac{km}{h}$, then this tells you that at this very instant the distance from you to Krakow is decreasing at a rate of 80 km per hour. This does not necessarily mean that after an hour you will be 80 km closer to Krakow (because your speed will most likely change many times), but at that very instant the distance is changing at this rate.

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In general the gradient function allows us to calculate the gradient of a function at a certain point. Suppose we have calculated that a gradient of our function at some point is 2. What does that mean?

This means that at this very point the function is increasing at a rate of 2. This does not however mean that if we move 1 to the right we should move 2 up, because the gradient of the function may change when we change x. However at our point the rate of change is 2.

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A process of finding a derivative is called **differentation**. We can differentiate a function as many times as we want. If we differentatiate a function $f(x)$ we get the derivative $f'(x)$. If we differentiate the derivative we get what's called the second derivative $f''(x)$. We can continue and get the third derivative $f'''(x)$ and so on.

A derivative describes the rate of change of the function. The second derivative is a derivative of a derivative, so it describes the rate of change of the derivative. In an example with a trip to Krakow if our function is the distance from Krakow, the derivative of this function is the velocity of the car (it describes how quickly the distance is changing). So the second derivative should describe the rate of change of the velocity of the car. This means that the second derivative would be the acceleration of the car.

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