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11. Computing partial derivatives

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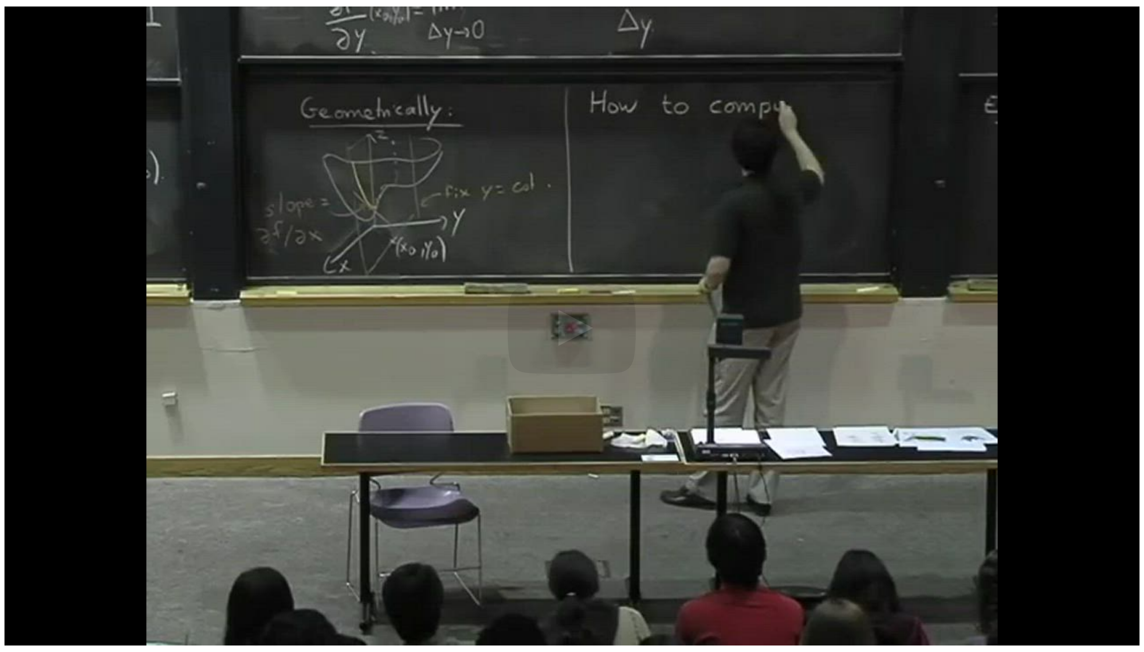

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PROFESSOR: So how to compute these things?

Oh, there's a piece of notation I haven't told you yet.

So another notation you will see,

I think this is what one uses a lot in physics

and this is what one uses a lot in applied math, which

is the same thing as physics but with different notations.

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To compute the partial derivative of $f(x, y)$ with respect to x, we treat y as a constant and differentiate each term with respect to x only. To illustrate this, let's first think about derivatives in the single variable case.

In order to compute

$$\frac{d}{dx}\sin(7x)$$

we use the chain rule to obtain

$$\frac{d}{dx}\sin(7x) = \cos(7x) \cdot \frac{d}{dx}(7x) = 7\cos(7x).$$

Now, let's say we want to compute

$$\frac{\partial}{\partial x}\sin(yx).$$

To do this, we use the chain rule as we did above, except now y is playing the role of 7. So we compute

$$\frac{\partial}{\partial x}\sin(yx) = \cos(yx) \cdot \frac{\partial}{\partial x}(yx) = y\cos(yx).$$

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This is what we mean when we say to treat y as a constant. Similarly, to compute the partial derivative of a function $f(x, y)$ with respect to y, we treat x as a constant and differentiate each term with respect to y only.

Let's do some worked examples before you get the chance to practice on your own.

Example 11.1 Consider $f(x, y) = x^2 + 3xy$. Then

$$\begin{aligned} f_x(x, y) &= \frac{\partial}{\partial x}(x^2 + 3xy) && (2.12) \\ &= \frac{\partial}{\partial x}x^2 + 3y\frac{\partial}{\partial x}x && (2.13) \\ &= 2x + 3y && (2.14) \end{aligned}$$

and

$$\begin{aligned} f_y(x, y) &= \frac{\partial}{\partial y}(x^2 + 3xy) && (2.15) \\ &= \frac{\partial}{\partial y}x^2 + 3x\frac{\partial}{\partial y}y && (2.16) \\ &= 0 + 3x && (2.17) \\ &= 3x. && (2.18) \end{aligned}$$

Example 11.2 Let $g(x, t) = \sin(x - 10t)$. Then

$$\begin{aligned} g_t(x, t) &= \frac{\partial}{\partial t}\sin(x - 10t) && (2.19) \\ &= \cos(x - 10t) \cdot \frac{\partial}{\partial t}(x - 10t) && (2.20) \\ &= -10\cos(x - 10t) && (2.21) \end{aligned}$$

and

$$\begin{aligned} g_x(x, t) &= \frac{\partial}{\partial x}\sin(x - 10t) && (2.22) \\ &= \cos(x - 10t) \cdot \frac{\partial}{\partial x}(x - 10t) && (2.23) \\ &= \cos(x - 10t). && (2.24) \end{aligned}$$

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