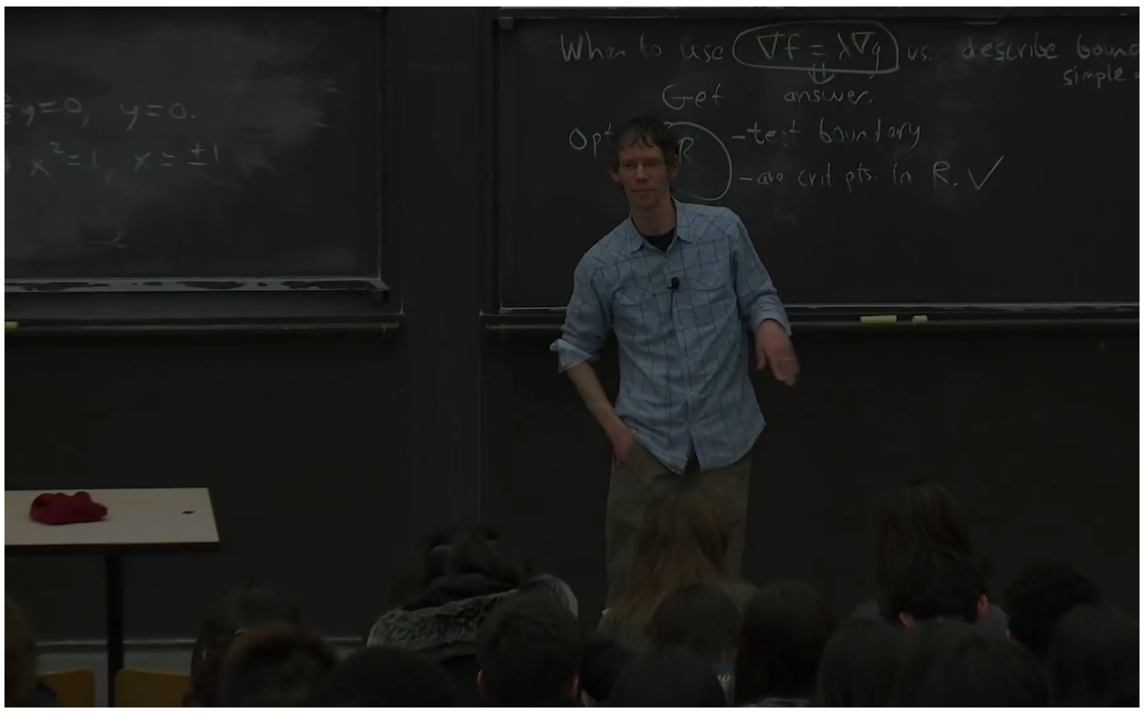
6. Q and A, constrained optimization

Discuss

Watch the video below, see if it answers any of the questions you have had about constrained optimization. If you have other questions, consider posting on the forum for clarification! If you don't have any other questions, consider trying to answer some of your fellow learner's questions!

Student q and a



19:42 / 19:42 2.0x

Actually, I should say that's the maximum of f.

Those are the maximum of points.

So now I try to do it with grad f equals lambda grad g.

Who's g? g is this, g is x squared plus 1/4 y squared.

So grad f is (2x, 2y), x lambda times

grad g, which is (2x, 1/2y).

I get two equations.

2x is lambda 2x, lambda times 2x.

2y is lambda times 1/2 y.

How might we approach this?

We have two equations, and we have three variables.

So there's a lot of algebra.

Something we might do is we could solve the first equation

to find lambda, and then we could plug that

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1. When do you use Lagrange multipliers, and when do you not?
   - See if you recognize something that makes it easy to compute the value of the function on the boundary.
   - Otherwise, use Lagrange multipliers. If you get an equation $1 = 1$, go back and see if there was something you missed.
2. How do we know if the critical points are in the region?
   - The region is defined by a level curve $g(x, y) = c$.
   - Determine if points inside are $g(x, y) < c$ or $g(x, y) > c$. (Let's pretend the inside is defined by $g(x, y) > c$ for this example.)
   - Evaluate the function g at the critical points. If $g > c$, the critical point is inside the region. If $g < c$, it must be outside.
3. If you are asked to find a vector that is perpendicular to another vector, how do you know which one to pick?
   - Any of the infinitely many vectors that are perpendicular to the given one will be graded as correct.
   - Sometimes you are given additional information. You may be asked to give a unit

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should be pointing in the direction the function is increasing or decreasing. So use any additional information to determine the direction and length.

4. How do you get from $\nabla f = \lambda \nabla g$ to a solution?

- $\nabla f = \lambda \nabla g$ gives you the system of equations

$$f_x = \lambda g_x \tag{7.59}$$

$$f_y = \lambda g_y \tag{7.60}$$

$$g(x,y) = c \tag{7.61}$$

One thing you can do is use one equation to solve for lambda, and then plug into the constraint equation $g(x,y) = c$ to solve for the other variable.

- Be careful solving for λ. Did you divide by something that might be zero? If yes, make sure to keep track of cases when the variable or expression is zero or not, and solve through each case independently. (See example below.)

Example 6.1

Find the maximum of the function $f(x,y) = x^2 + y^2$ on the ellipse $x^2 + \frac{1}{4}y^2 = 1$.

The equation $\nabla f = \lambda \nabla g$ says that

$$2x = \lambda 2x \tag{7.62}$$

$$2y = \lambda y/2 \tag{7.63}$$

We can use the first equation to solve for λ. This gives us two cases to consider: $\lambda = 1$ or $x = 0$.

If $\lambda = 1$, then the second equation gives us

$$2y = y/2, \tag{7.64}$$

which is true only if $y = 0$. Plugging this into our equation for g, we get

$$x^2 + \frac{1}{4}(0)^2 = 1,$$

which tells us that $x = \pm 1$. Therefore we get the two points $(\pm 1, 0)$.

On the other hand, if $x = 0$, the we can solve for y directly from g, and we find that

$$0^2 + \frac{1}{4}y^2 = 1,$$

which tells us that $y = \pm 2$. Therefore we get the two points $(0, \pm 2)$. You can verify for yourself that the points $(0, \pm 2)$ are the maximum and the points $(\pm 1, 0)$ are the minimum of f restricted to the ellipse $x^2 + \frac{1}{4}y^2 = 1$.

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