

<u>Help</u>

sandipan\_dey ~

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☆ Course / Unit 3: Optimization / Lecture 11: Lagrange Multipliers



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### **Summarize**

#### **Big Picture**

A differentiable function  $f\left(x,y
ight)$  of two variables on a closed bounded region R attains an absolute maximum (and absolute minimum) on  $oldsymbol{R}$ .

- The absolute maximum (or minimum) occurs at a critical point, or
- ullet the absolute maximum (or minimum) occurs on the boundary of R.

**Key point 1**: Along the boundary, the maximum occurs when the gradient abla f is normal (perpendicular) to the boundary.

**Key point 2** : If the boundary of the region R is described as the level curve  $g\left(x,y
ight)=k$ . Then the maximum occurs where  $\nabla f$  and  $\nabla g$  point in the same (or opposite) direction:

$$oxed{
abla f = \lambda 
abla g}$$

#### **Mechanics**

The method of **Lagrange multipliers** is used to optimize a function  $f\left(x,y
ight)$  (find the max or min) along a curve Cdescribed as a level curve g(x,y)=k for some function g(x,y). The curve C is called the **constraint**. A summary of the steps is given below.

1. Solve the following system of equations

$$f_x(x,y) = \lambda g_x(x,y) \tag{4.193}$$

$$f_y(x,y) = \lambda g_y(x,y)$$
 (4.194)

$$g(x,y) = k (4.195)$$

for  $\boldsymbol{x}$  and  $\boldsymbol{y}$ . (The scalar  $\boldsymbol{\lambda}$  is called the **Lagrange multiplier**.)

- 2. Compute the value of f(x,y) at each point found in Step 1.
- 3. Identify which points give the maxima and minima of f(x,y).

#### **Ask Yourself**

### → How do you determine which function plays which role?

The function  $m{f}$  is the function whose maximum and minimum we want to find. The function  $m{g}$  describes the constraint.

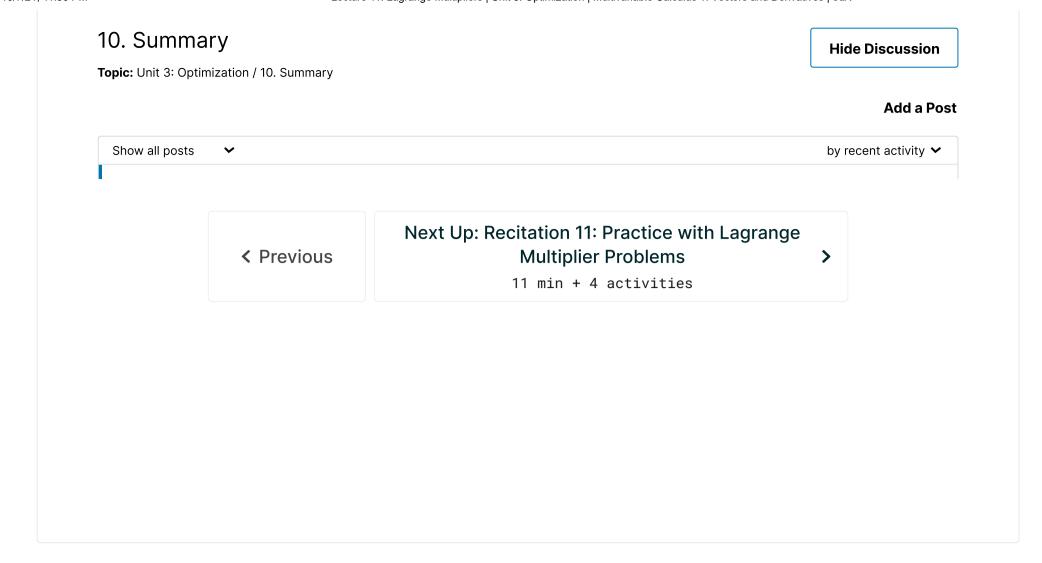
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#### ✓ If a function is only defined along a curve and has no meaning otherwise, do you still check critical points?

No! If you only care about a function along a curve C, the restricted domain is this curve, and not the interior. In this case, it is enough to find the maximum and minimum along the boundary. Note that any critical points along the boundary will be found by the method of Lagrange Multipliers already!

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