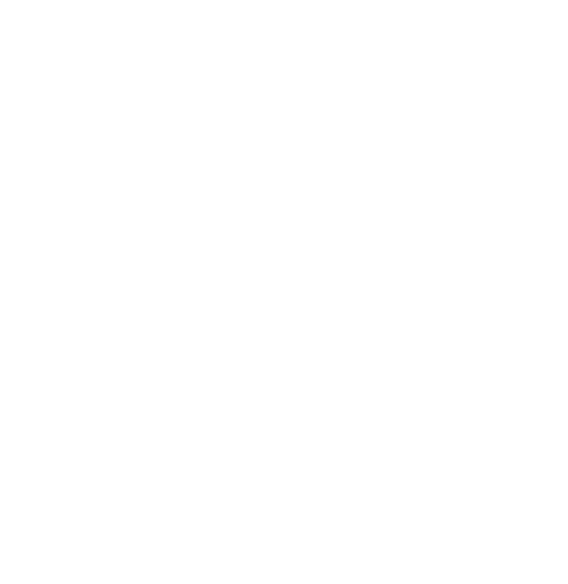
**Lagrange Multipliers**

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When we get a problem that goes along the lines of ‘Maximize the area of..’ or ‘Minimize the area of..’, these are called **optimization problems**. Some optimization problems have additional **constraints** on the values that can be used to produce the solution. Such constraints tend to complicate things, so we will now study a method to deal with them.

Consider that we have an **ellipse**, , which has a **rectangle inscribed** inside of it. The top-right corner of the rectangle is at the point .



Since the rectangle has sides of length and , the **area** of the rectangle can be found by:

Since the rectangle is inscribed in the ellipse, our choice of is **constrained** to the **first-quadrant** point that **lie on the ellipse**.

We solve this problem using the equation below.

The scalar multiple is called the **Lagrange Multiplier**.

This leads to three equations:

Note that this method cannot be used if or are .

For the example we were studying,

Thus,

Since ,

We previously said that the point must be in the **first quadrant**, so , which gives us . Ignoring the negative value of for the same reason, the extrema point is at .

The area is

In the above example, we only got a **single possible critical point**. However, say we get **multiple possible critical points**. In that scenario, all the critical points are **extrema**, but we do not know which are maximum and which are minimum. We can simply **calculate** the results and **compare** to determine this.

The Lagrange Multiplier is used in economics as well, where it is called the **marginal productivity** of money.

## Two Constraints

If we have **two constraints**, we can use a second Lagrange multiplier, .