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3. Single vs. multivariable

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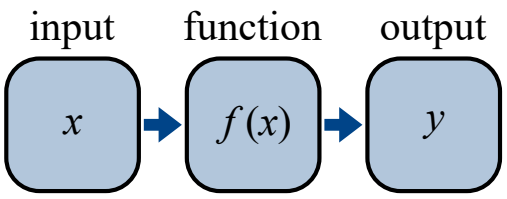
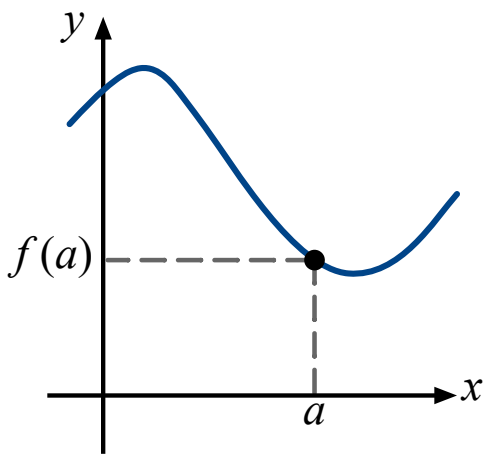
Single vs. multivariable

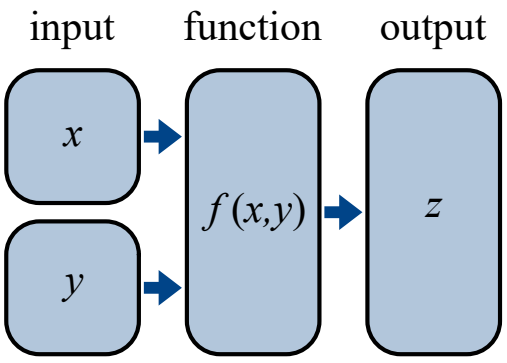
In single variable calculus, you saw functions of one variable $y = f(x)$. This type of function acts as a rule that assigns one output value y to one input value x. In other words, the function $f(x)$ acts like a machine that takes in x-values and produces y-values. A schematic of this idea is shown below.



On a graph, this same idea is illustrated on the x- and y-axes below, where we indicate a specific x-value given by $x = a$ and its corresponding y-value given by the height $f(a)$.

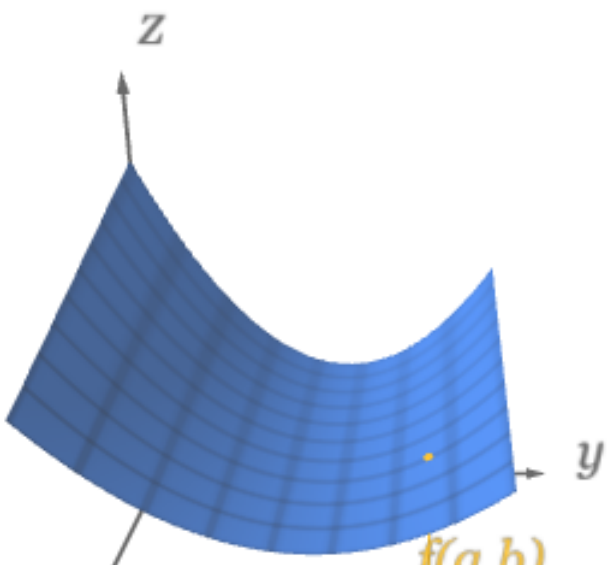


In multivariable calculus, we will deal with functions that have multiple inputs. A function of two variables $z = f(x, y)$ is a rule that assigns one output value z to two input values x and y. In other words, the function $f(x, y)$ acts like a machine that takes in x- and y-values and produces z-values.



On a graph, this same idea is illustrated on the x-, y-, and z-axes below, where we indicate specific x- and y-values given by $(x, y) = (a, b)$ and the corresponding z-value given by the height $f(a, b)$.

▶ **A function $z = f(x, y)$**



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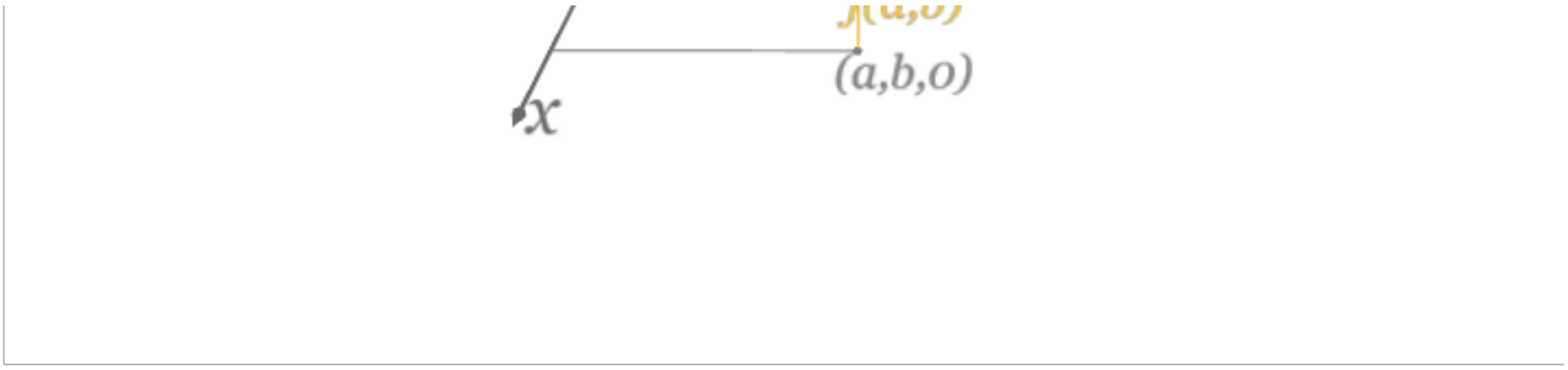
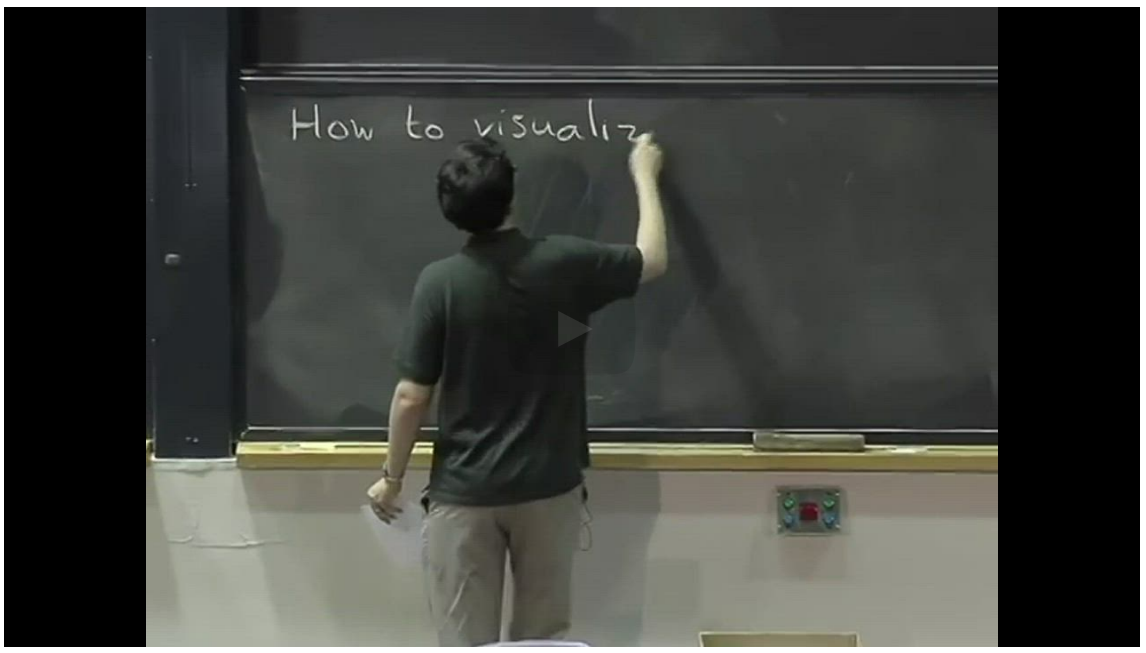


How to graph functions of two variables



0:00 / 0:00 2.0x

Start of transcript. Skip to the end.

PROFESSOR: So the first thing we can do

is try to draw the graph of f.

So maybe I should say f, which is a function of two variables.

So the first answer will be we can try to look at its graph.

And the idea is the same as with one variable, namely,

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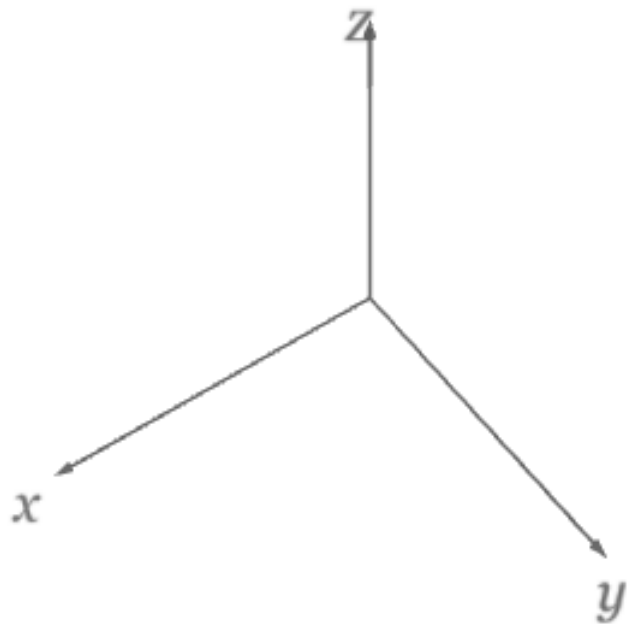
We can visualize functions of two variables as three-dimensional surfaces. The standard way of doing this is to have 3 mutually orthogonal axes where the xy-axes span a horizontal plane and the z axis is vertical and perpendicular to the xy-plane. The xy-plane consists of the input variables. The variable z represents the output of the function and is depicted as the height of the graph.

▶ **Coordinate axes in 3D**



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Remark 3.1

Note that the x- and y- and z-axes are oriented with respect to a right hand rule. We will always use this same orientation. But the viewpoint may be different.

- Denis Auroux draws axes with the positive z-axis pointing straight up, the positive x-axis coming out of the board towards you, and the positive y-axis to the right. This is the standard orientation for static 3D images.

- Larry Guth draws axes with the positive z-axis pointing straight up, the positive x-axis to the right, and the positive y-axis into the board. This orientation makes the connection between the 3D graph and the 2D plot of level curves clearer (see the next page) where the x-axis is horizontal and the y-axis is vertical.

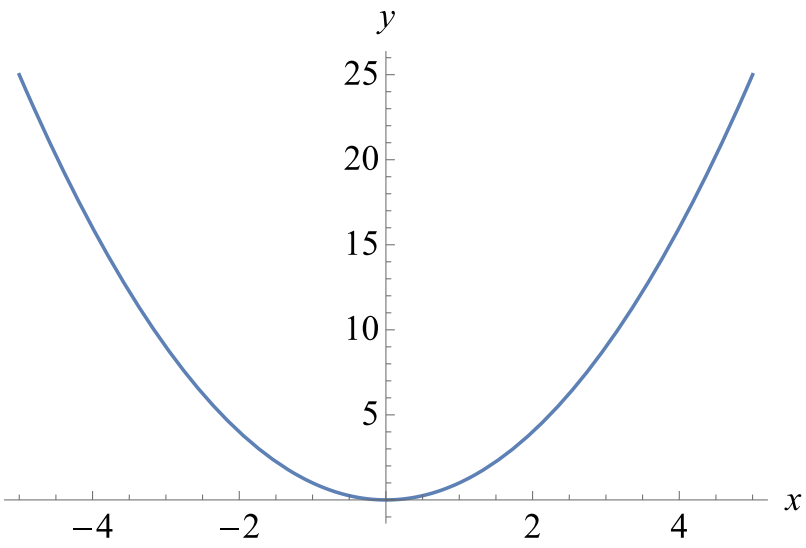
- Our web based 3D images can be rotated. The initial viewpoint we give you will be one which best allows you to see the surface, and we may use the standard view, a view that connects more clearly with 2D plots of level curves, or a more symmetric view as above. We encourage you to explore the images by rotating them to get a better overall sense of the shape.

Example 3.2

A function of one variable that you saw in single variable calculus is

$$f(x) = x^2. \tag{2.1}$$

The graph of $f(x)$ is shown below.



In 3 dimensions, we can graph a related function given by

$$f(x, y) = x^2 + y^2. \tag{2.2}$$

▶ **PARABOLOID**

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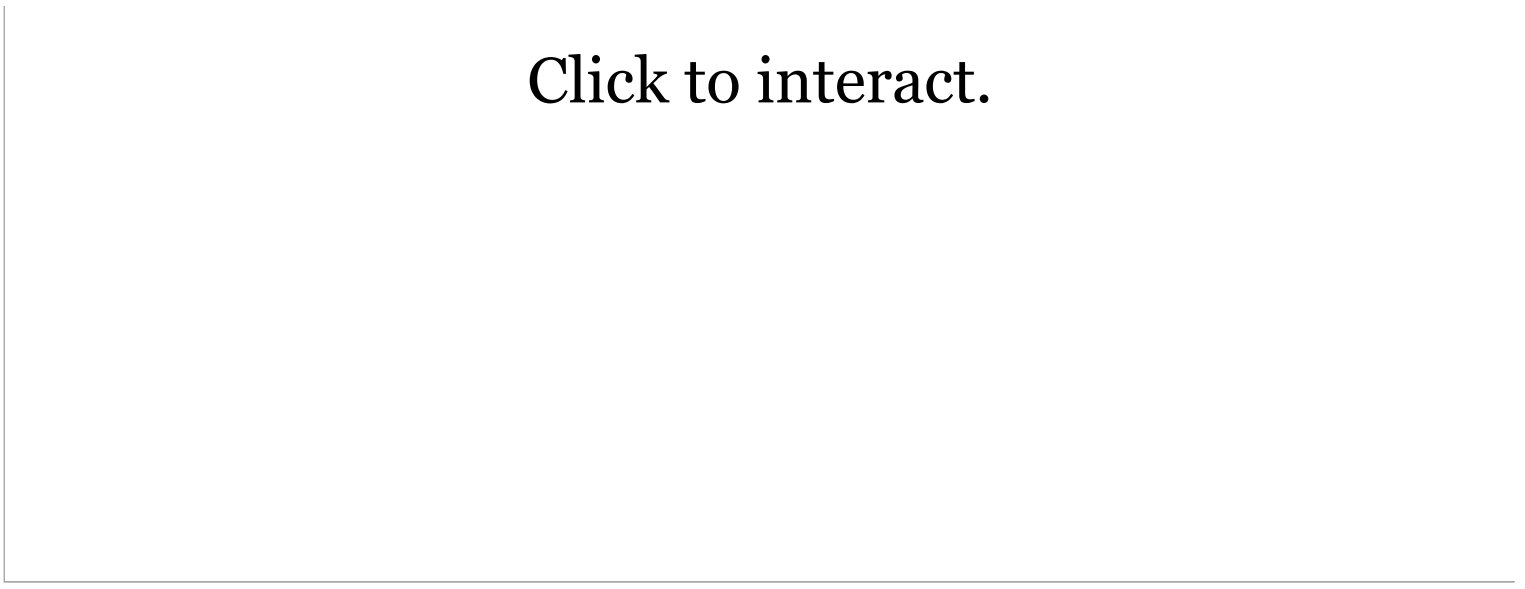

3. Single vs. multivariable

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- What are the 2 3D static orientations? — 6
  In the remarks, the static orientations favoured by Denis Auroux and Larry Guth are described but I'm not totally sure what is meant. ...
- What was the notation the professor erased? — 4
  I'm not sure if I've encountered it before.
- [STAFF] Extension — 6
  I know it's too early but any chance we could get an extension on this? I am working full time and only got a chance to change to the...
- Geogebra — 10
  For anyone who wishes to explore different surfaces I recommend the site geogebra.org, especially their [3D calculator][1] which ma...
- Right hand rule — 2
  Better explained - https://www.youtube.com/watch?v=5sJdfciNM20

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