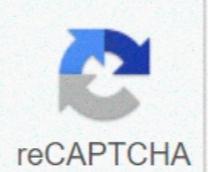


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Implicit differentiation word problems and solutions pdf

In our work up until now, the functions we needed to differentiate were either given explicitly, such as $y = x^2 + e^x$, or it was possible to get an explicit formula for them, such as solving $y^3 - 3x^2 = 5$ to get $y = \sqrt[3]{5 + 3x^2}$. Sometimes, however, we will have an equation relating y and y' which is either difficult or impossible to solve explicitly for y , such as $y + e^y = x^2$. In any case, we can still find $y' = f(x)$ by using implicit differentiation. The key idea behind implicit differentiation is to assume that y is a function of x even if we cannot explicitly solve for y . This assumption does not require any work, but we need to be very careful to treat y as a function when we differentiate and to use the Chain Rule. To view this video please enable JavaScript, and consider upgrading to a web browser that supports HTML5 video. Assume that y is a function of x . Calculate $\frac{d}{dx} \left(y^3 - 3x^2 \right)$ using the chain rule since y is a function of x : $\frac{d}{dx} \left(y^3 - 3x^2 \right) = 3y^2 \frac{dy}{dx} + 0$. We need to use the product rule and the Chain Rule: $\frac{d}{dx} \left(y^3 - 3x^2 \right) = x^3 \frac{d}{dx} \left(y^3 \right) + 0 = x^3 \cdot 3y^2 \frac{dy}{dx} + 0$. We know $\frac{d}{dx} \left(\ln(x) \right) = \frac{1}{x}$, so we use that and the Chain Rule: $\frac{d}{dx} \left(\ln(y) \right) = \frac{1}{y} \cdot y' = \frac{1}{y} \cdot y'$. To determine y' , differentiate each side of the defining equation, treating y as a function of x , and then algebraically solve for y' . To view this video please enable JavaScript, and consider upgrading to a web browser that supports HTML5 video. (The last example in the following video gets rather messy - don't worry too much if you can't follow all of the simplifications at the end.) To view this video please enable JavaScript, and consider upgrading to a web browser that supports HTML5 video. Find the slope of the tangent line to the circle $x^2 + y^2 = 25$ at the point $(3, 4)$ using implicit differentiation. We differentiate each side of the equation $x^2 + y^2 = 25$ and then solve for y' : $\frac{d}{dx} \left(x^2 + y^2 \right) = 0$. Solving for y' , we have $y' = -\frac{2x}{y}$. Because we could explicitly solve for y , we had a choice of methods for calculating y' . Sometimes, however, we cannot explicitly solve for y , and the only way of determining y' is to use implicit differentiation. To view this video please enable JavaScript, and consider upgrading to a web browser that supports HTML5 video. If several variables or quantities are related to each other and some of the variables are changing at a known rate, then we can use derivatives to determine how rapidly the other variables must be changing. Here is a link to the examples used in the videos in this section: Related Rates. To view this video please enable JavaScript, and consider upgrading to a web browser that supports HTML5 video. Suppose the border of a town is roughly circular, and the radius of that circle has been increasing at a rate of 0.1 miles each year. Find how fast the area of the town has been increasing when the radius is 5 miles. We could get an approximate answer by calculating the area of the circle when the radius is 5 miles ($A = \pi r^2 = \pi (5 \text{ miles})^2 \approx 78.5 \text{ square miles}$) and 1 year later when the radius is 0.1 feet larger than before ($A = \pi r^2 = \pi (5.1 \text{ miles})^2 \approx 81.7 \text{ square miles}$) and then finding $\frac{\Delta A}{\Delta t} = \frac{81.7 - 78.5}{1} = 3.1 \text{ square miles per year}$. This approximate answer represents the average change in area during the 1 year period when the radius increased from 5 miles to 5.1 miles, and would correspond to the secant slope on the area graph. To find the exact answer, though, we need derivatives. In this case both radius and area are functions of time: $r(t) = \text{radius at time } t$, $A(t) = \text{area at time } t$. We know how fast the radius is changing, which is a statement about the derivative: $\frac{dr}{dt} = 0.1 \text{ miles per year}$. We also know that $r = 5$ at our moment of interest. We are looking for how fast the area is increasing, which is $\frac{dA}{dt}$. Now we need an equation relating our variables, which is the area equation: $A = \pi r^2$. Taking the derivative of both sides of that equation with respect to t , we can use implicit differentiation: $\frac{dA}{dt} = \frac{d}{dt} (\pi r^2) = \pi r^2 \frac{dr}{dt}$. Plugging in the values we know for r and $\frac{dr}{dt}$, we have $\frac{dA}{dt} = \pi (5)^2 (0.1) = 78.5 \text{ square miles per year}$. So the area of the town is increasing by approximately 78.5 square miles per year when the radius is 5 miles. When working with a related rates problem, Draw a picture (if possible). Identify the quantities that are changing, and assign them variables. Find an equation that relates those quantities. Differentiate both sides of that equation with respect to time. Plug in any known values for the variables or rates of change. Solve for the desired rate. To view this video please enable JavaScript, and consider upgrading to a web browser that supports HTML5 video. A company has determined the demand curve for their product is $q = \sqrt{5000 - p^2}$, where p is the price in dollars, and q is the quantity in millions. If weather conditions are driving the price up \$2 a week, find the rate at which demand is changing when the price is \$40. The quantities changing are p and q , and we assume they are both functions of time, t , in weeks. We already have an equation relating the quantities, so we can implicitly differentiate it: $\frac{dq}{dt} = \frac{d}{dt} (\sqrt{5000 - p^2}) = \frac{1}{2\sqrt{5000 - p^2}} \cdot (5000 - p^2)^{-1/2} \cdot (-2p) = \frac{-p}{\sqrt{5000 - p^2}} \cdot \frac{1}{2} \cdot (-2) = \frac{p}{\sqrt{5000 - p^2}} \cdot (-1)$. Using the given information, we know the price is increasing by \$2 per week when the price is \$40, giving $\frac{dp}{dt} = 2$ when $p = 40$. Plugging in these values, $\frac{dq}{dt} = \frac{40}{\sqrt{5000 - 40^2}} \cdot (-1) \approx -1.37$. Demand is falling by 1.37 million items per week. To view this video please enable JavaScript, and consider upgrading to a web browser that supports HTML5 video. To view this video please enable JavaScript, and consider upgrading to a web browser that supports HTML5 video. If you're seeing this message, it means we're having trouble loading external resources on our website. If you're behind a web filter, please make sure that the domains *.kasandbox.org and *.kastatic.org are unblocked. Implicit Differentiation Notes and Examples In our work up until now, the functions we needed to differentiate were either given explicitly, such as $y = x^2 + e^x$, or it was possible to get an explicit formula for them, such as solving $y^3 - 3x^2 = 5$ to get $y = \sqrt[3]{5 + 3x^2}$. Sometimes, however, we will have an equation relating y and y' which is either difficult or impossible to solve explicitly for y , such as $y + e^y = x^2$. In any case, we can still find $y' = f(x)$ by using implicit differentiation. The key idea behind implicit differentiation is to assume that y is a function of x even if we cannot explicitly solve for y . 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