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How to solve for point of intersection

© 2008 Rasmus ehf. og Jóhann skóli Lesson 3 Intersection points of graphs How do we get about finding the points in which two graphs $y = f(x)$ and $y = g(x)$ intersect? We already know how to find where the graph of $f(x)$ cuts the x -axis. That's where $y = 0$. We calculate it by solving the equation $f(x) = 0$. When the graphs of $y = f(x)$ and $y = g(x)$ intersect, both graphs have exactly the same x and y values. So we can find the point or points of intersection by solving the equation $f(x) = g(x)$. The solution of this equation will give us the x value(s) of the point(s) of intersection. We can then find the y value by putting the value for x that we have found into one of the original equations. That is: $2x - 1 = 3$ The point of intersection is $(2, 3)$. The example shows that we can find the point of intersection in two ways. Either graphically, by drawing the two graphs in the same coordinate system, or algebraically by solving the equation such as the one in the above example. Solving

Example 4: We draw the graphs of $f(x) = x^2 - 2x - 3$ and $g(x) = 2x - 3$ by making a table of values and plotting the points. We can see, both from the graph and from the table of values, that the graphs intersect when $x = 0$ and $x = 4$. Solving algebraically: $x^2 - 2x - 3 = 2x - 3$ $x^2 - 4x = 0$ $x(x - 4) = 0$ Giving the solutions $x = 0$ and $x = 4$. Example 3 Solve the equation $x^2 - 1 = 2x - 3$ First move all the terms over to the left hand side of the equation and simplify. This gives $x^2 - 2x + 2 = 0$ We use the quadratic formula with $a = 1$, $b = -2$ and $c = 2$. The number under the square root sign is negative which means this equation has no solution. To see why this we draw the graphs of the left hand side of the original equation $f(x) = x^2 - 1$ and the right hand side $g(x) = 2x - 3$. We see that the parabola $f(x)$ and the straight line $g(x)$ do not intersect. It's easy to see that we cannot calculate the point of intersection simply because there is no such point. Example 4 Solve the equation $x^3 - 3x + 2 = x^2 - 2x + 1$ As in the previous example we move all the terms over to the left hand side of the equation, $x^3 - 3x + 2 = x^2 - 2x + 1$ $x^3 - x^2 - x + 1 = 0$ $(x^3 - x^2) - (x - 1) = 0$ $x^2(x - 1) - (x - 1) = 0$ $(x - 1)(x^2 - 1) = 0$ $(x - 1)(x - 1)(x + 1) = 0$ Calculations show that there are only two solutions, $x = 1$ and $x = -1$, but a cubic equation can have three solutions. The graph shows us what is happening. The graphs of $f(x) = x^2 - 2x + 1$ and $g(x) = x^3 - 3x + 2$ intersect in only two places, where $x = -1$ and $x = 1$ which were the solutions of the equation. Example 5 Solve the equation $x^2 = x$ It's easy to see that $x = 0$ and $x = 1$ are solutions of the equation but are there any more solutions? It's not

Here's how to solve the equation by calculation: $x^2 = x + x - x$, $x^4 = x + x(x^3 - 1) = 0$. Draw graphs both sides of the equation to get rid of the square root. This gives the solution $x = 0$ and $x = 1$. Example 6 Solve the equation $\ln x = x^2 - 1$. This equation is not so easy to solve. If we remember the definition of a logarithm we can see that $x = 1$ makes both sides of the equation equal to 0 and is therefore one solution to the equation. We draw graphs just as if there are any other solutions.

The graph shows us that there are two solutions. One solution is exactly $x = 1$ because $e^0 = 1$. Notice that we choose the x values so that the y values become nearer and nearer to each other in the table of values. In this way we can choose the x value to get the accuracy we want. Example 7 EXCEL If we use a graphical calculator we can find the solution of the equation $\ln x = x^2 - 1$ much more easily. We draw the graphs of both sides of the equation and use Zoom (shift F2) and then Trace (shift F1) to find the point of intersection. Even easier is to use the G-Solve (F5) and then the intersection function ISCT (F5). This gives us the first point of intersection. We then press the right arrow and the calculator will move on to the second intersection point. The spreadsheet program EXCEL has a tool called "goal seek" to solve equations that can't easily be solved algebraically. Start by rearranging the equation as shown. $\ln x = x^2 - 1 \Rightarrow \ln x - x^2 + 1 = 0$ In Open EXCEL and begin by choosing or guessing a starting value for x . Enter this into cell B2. We can, for example choose 0.1. Next we put the formula that we have on the right hand side of the equation, $x^2 - \ln x$, into cell D2. The formula will look like this: $=B2^2 - \ln(B2)$ Now choose "Tools" and then "Goal Seek" on the menu bar. The following appears on the screen: We write D2, 1 and B2 in the spaces as shown. We are asking EXCEL to make make the value of cell D2 equal to the value 1 by changing the value in B2. When we click on OK the following information appears. This tells us that the approximation $x = 0.45$ that we found graphically in example 6 is pretty good. The solution $x = 0.450289$ found by using EXCEL is not much better. Try Quiz 3 on Equations 11. Remember to use the checklist to keep track of your work. A system of linear equations includes two or more linear equations. The graphs of two lines will intersect at a single point if they are not parallel. Two parallel lines can also intersect if they are coincident, which means they are the same line and they intersect at every point. For two lines that are not parallel, the single point of intersection will satisfy both equations and therefore represent the solution to the system. To find this point when the equations are given as functions, we can

[A] [latex]\begin{cases} x=3t-4 \\ y=t \end{cases} and [B] [latex]\begin{cases} x=9t \\ y=t \end{cases}. This tells us the lines intersect when the input is $\frac{9}{4}$. We can then find the output value of the intersection point by evaluating either function at this input. If we are asked to find the point of intersection of two distinct parallel lines, should something in the solution process alert us to the fact that there are no solutions? After setting the two equations equal to one another, the result would be the contradiction "0 = non-zero real number". Using the graph in the Analysis of the Solution for Example 12, identify the following for the function $y=\frac{1}{x}$: a. y-intercept b. x-intercept(s) c. slope d. Is $y=\frac{1}{x}$ parallel or perpendicular to $y=x$? e. Is $y=\frac{1}{x}$ increasing or decreasing function (or neither)? f. Write a transformation description for $y=\frac{1}{x}$.

Solution A company sells sports helmets. The company incurs a one-time fixed cost for \$250,000. Each helmet costs \$120 to produce, and sells for \$140. Find the cost function, C, to produce x helmets, in dollars. Find the revenue function, R, from the sales of x helmets, in dollars. Find the break-even point, the point of intersection of the two graphs C and R. The cost function in the sum of the fixed cost, \$125,000, and the variable cost, \$120 per helmet.

The revenue function, R, is $R(x)=140x$. The revenue function is the total revenue from the sale of x helmets. The break-even point is the point of intersection of the graph of the cost and revenue functions. To find the x-coordinate of the coordinate pair of the point of intersection, set the two equations equal, and solve for x. $125,000+120x=140x$

To find y , evaluate either the revenue or the cost function at 12,500.

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