Lesson 16 **Part 1: Introduction**

Solve Systems of Equations Algebraically

CCLS
8.EE.C.8b

You know that solutions to systems of linear equations can be shown in graphs. Now you will learn about other ways to find the solutions. Take a look at this problem.

Sienna wrote these equations to help solve a number riddle.

$y = x - 20$

$x + y = 84$

What values for x and y solve both equations?

Explore It

Use math you already know to solve the problem.

- What does $y = x - 20$ tell you about the relationship between x and y?

- What does $x + y = 84$ tell you about the relationship between x and y?

- You can guess and check to solve the problem. Try 44 for x and 40 for y. Do these numbers solve both equations?

- Now try 50 for x. If $x = 50$, what is y when $y = x - 20$? Does that work with the other equation?

- Try $x = 52$. What do you find?

- Explain how you could find values for x and y that solve both equations.

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Find Out More

In Lesson 15, you learned that without actually solving, you can tell if a system of equations will have exactly one solution, no solution, or infinitely many solutions. Here are some examples.

$x + y = 6$ $2x + 2y = 12$	The second equation is double the first one, so they are the same equation with the same graph and solution set. This system has infinitely many solutions.

$5x + y = 3$ $x = 4 - 5x$	If you write both equations in slope-intercept form, you find that $y = -5x + 4$ and $y = -5x + 3$. The lines have the same slope and different intercepts so they are parallel. This system has no solutions.

If a system of equations has exactly one solution, like the problem on the previous page, there are different ways you can find the solution.

You could guess and check, but that is usually not an efficient way to solve a system of equations. You could graph each equation, but sometimes you can't read an exact answer from the graph. Here is one way to solve the problem algebraically.

$y = x - 20$ $x + y = 84$	Substitute $x - 20$ for y in the second equation and solve for x. $x + (x - 20) = 84$ $2x - 20 = 84$ $2x = 104$ $x = 52$, so $y = 32$

You will learn more about algebraic methods later in the lesson.

Reflect

1 How does knowing $x = 52$ help you find the value of y?

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Read the problem below. Then explore how to use substitution to solve systems of equations.

Solve this system of equations.

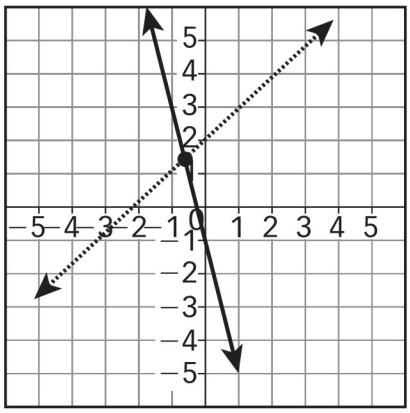
$y = x + 2$

$y + 1 = -4x$

Graph It

You can graph the equations and estimate the solution.

Find the point of intersection. It looks like the solution is close to $\left(-\frac{1}{2}, 1\frac{1}{2}\right)$.



Model It

You can use substitution to solve for the first variable.

Notice that one of the equations tells you that $y = x + 2$. This allows you to use substitution to solve the system of equations.

Substitute $x + 2$ for y in the second equation.

$y = x + 2$

$y + 1 = -4x$

$(\boldsymbol{x + 2}) + 1 = -4x$

Now you can solve for x.

$x + 2 + 1 = -4x$

$x + 3 = -4x$

$3 = -5x$

$x = -\frac{3}{5}$

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Connect It

Now you will solve for the second variable and analyze the solution.

2 What is the value of x? How can you find the value of y if you know the value of x?

3 Substitute the value of x in the equation $y = x + 2$ to find the value of y.

4 Now substitute the value of x in the equation $y = -4x - 1$ to find the value of y.

5 What is the ordered pair that solves both equations? Where is this ordered pair located on the graph?

6 Look back at Model It. How does substituting $x + 2$ for y in the second equation give you an equation that you can solve?

7 How does substitution help you to solve systems of equations?

Try It

Use what you just learned to solve these systems of equations. Show your work on a separate sheet of paper.

8 $y - 3 = 2x$
$y = 4x - 2$

9 $y = 1.4x + 2$
$y - 3.4x = -2$

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Read the problem below. Then explore how to solve systems of equations using elimination.

Solve this system of equations.

$-x - 2y = 4$

$3y = -0.5x + 2$

Model It

You can use elimination to solve for one variable.

First, write both equations so that like terms are in the same position. Then try to eliminate one of the variables, so you are left with one variable. To do this, look for a way to get opposite coefficients for one variable in the two equations.

$-2y = x + 4$

$3y = -0.5x + 2$

$2(3y = -0.5x + 2)$
$6y = -x + 4$

- Multiply the second equation by 2. Now you have opposite terms: x in the first equation and $-x$ in the second equation.

$-2y = x + 4$
$6y = -x + 4$
$4y = 8$

- Add the like terms in the two equations. The result is an equation in just one variable.

$y = 2$

- Divide each side by 4 to solve the equation for y.

$-2(2) = x + 4$
$-x - 4 = 4$
$-x = 8$
$x = -8$

- Substitute the value of y into one of the original equations and solve for x.

Check:
$3(2) = -0.5(-8) + 2$
$6 = 4 + 2$

- Substitute your solution in the other original equation.

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Connect It

Now analyze the solution and compare methods for solving systems of equations.

10 What happens when you add opposites? Why do you want to get opposite coefficients for one of the variables? _____

_____

11 How did you get opposite coefficients for x in the solution on the previous page?

_____

12 Why does the equation stay balanced when you add the values on each side of the equal sign? _____

_____

_____

13 Which equation in the system was used to find the value of x? _____ Can you use the other equation? Explain. _____

_____

14 How is elimination like substitution? How is it different? _____

_____

_____

_____

15 How can you check your answer? _____

_____

Try It

Use what you just learned about elimination to solve this problem. Show your work on a separate sheet of paper.

16 $2x + y = 9$

$3x - y = 16$

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Study the model below. Then solve problems 17–19.

Student Model

Solve this system of equations.

$3y = x + 1$
$2y = 6x - 2$

Look at how you could use substitution to solve a system of equations.

$\frac{2y = 6x - 2}{2}$

$y = 3x - 1$

Since $y = 3x - 1$, I can substitute $3x - 1$ for y in the first equation.

$3(3x - 1) = x + 1$
$9x - 3 = x + 1$
$8x = 4$
$x = \frac{1}{2}$
$3y = \frac{1}{2} + 1; y = \frac{1}{2}$

Solution: $\left(\frac{1}{2}, \frac{1}{2}\right)$

The student divided each term in the equation $2y = 6x - 2$ by 2 to get an expression equal to y.

Pair/Share

Solve the problem using elimination.

Can it help to write both equations in the same form?

Pair/Share

Discuss your solution methods. Do you prefer using substitution or elimination?

17 What ordered pair is a solution to $y = x + 5$ and $x - 5y = -9$?

Show your work.

Solution: _____

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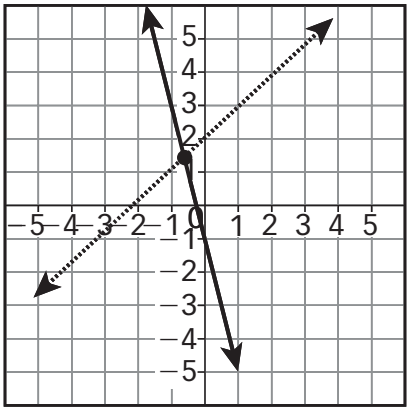
18 Graph the equations. What is your estimate of the solution of this system of equations?

$y = 3x - 2$
$y = -2x$

Show your work.



Solution: _____

Do the equations have the same or different slopes?

Pair/Share

Solve the problem algebraically and compare the solution to your estimate.

19 Which of these systems of equations has no solution?

A $y = \frac{x}{4} + 2$
$y = 4x - 1$

B $y = \frac{2x}{3} - 3$
$y = 2x - 3$

C $y = 4x$
$y = 4x - 5$

D $x + y = 3$
$2y = -2x + 6$

Sheila chose **D** as the correct answer. How did she get that answer?

_____

_____

_____

What do you know about the lines in a system of equations with no solution?

Pair/Share

Graph the solution to verify your answer.

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