BARTLETT

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# Unit 6, Lesson 9: Dealing with Negative Numbers

Let's show that doing the same to each side works for negative numbers too.

5 mins. 1 min think, partner, class

## 9.1: Which One Doesn't Belong: Rational Number Arithmetic

Which equation doesn't belong?

$15 = -5 \cdot -3$ - solution on L

$4 - -2 = 6$ - subtraction

$2 + -5 = -3$ - addition

$-3 \cdot -4 = -12$ - not true

## 9.2: Old and New Ways to Solve

10 mins. 5 mins. work, discussion

Solve each equation. Be prepared to explain your reasoning.

"do the same thing on both sides"

1. $x + 6 = 4$ $x = -2$
2. $x - -4 = -6$ $x = -10$
3. $2(x - 1) = -200$ $x = -99$
4. $2x + -3 = -23$ $x = -10$

## 9.3: Keeping It True

10 mins. 2 mins. work, partner, discuss

Here are some equations that all have the same solution.

$x = -6$

$x - 3 = -9$ ← subtract 3 from each

swap two sides of equation → $-9 = x - 3$

$900 = -100(x - 3)$ ← multiply each side by -100

commutative property → swap factors -100 & x - 3 → $900 = (x - 3) \cdot (-100)$

$900 = -100x + 300$ ← apply distributive property

1. Explain how you know that each equation has the same solution as the previous equation. Pause for discussion before moving to the next question.

2. Keep your work secret from your partner. Start with the equation $-5 = x$. Do the same thing to each side at least three times to create an equation that has the same solution as the starting equation. Write the equation you ended up with on a slip of paper, and trade equations with your partner.

3. See if you can figure out what steps they used to transform $-5 = x$ into their equation. When you think you know, check with them to see if you are right.

# Unit 6, Lesson 10: Different Options for Solving One Equation

Let's think about which way is easier when we solve equations with parentheses.

5 mins.

### 10.1: Algebra Talk: Solve Each Equation

$100(x-3) = 1{,}000$ 13 = $x$

$500(x-3) = 5{,}000$ 13 = $x$

$0.03(x-3) = 0.3$ 13 = $x$

$0.72(x+2) = 7.2$ 8 = $x$

$\frac{1}{7}(x+2) = \frac{10}{7}$ 8 = $x$

### 10.2: Analyzing Solution Methods

10 mins.

Three students each attempted to solve the equation $2(x-9) = 10$, but got different solutions. Here are their methods. Do you agree with any of their methods, and why?

Noah's method:

Disagree – distribute 2 first

$$2(x-9) = 10$$
$$2(x-9) + 9 = 10 + 9 \quad \text{add 9 to each side}$$
$$2x = 19$$
$$2x \div 2 = 19 \div 2 \quad \text{divide each side by 2}$$
$$x \neq \frac{19}{2}$$

Elena's method:

Disagree – don't subtract 18, add it

$$2(x-9) = 10$$
$$2x - 18 = 10 \quad \text{apply the distributive property}$$
$$2x - 18 - 18 = 10 - 18 \quad \text{subtract 18 from each side}$$
$$2x = -8$$
$$2x \div 2 = -8 \div 2 \quad \text{divide each side by 2}$$
$$x = -4$$

Andre's method:

Agree, all true

$$2(x-9) = 10$$
$$2x - 18 = 10 \quad \text{apply the distributive property}$$
$$2x - 18 + 18 = 10 + 18 \quad \text{add 18 to each side}$$
$$2x = 28$$
$$2x \div 2 = 28 \div 2 \quad \text{divide each side by 2}$$
$$x = 14$$

NAME DATE PERIOD

## 10.3: Solution Pathways

$3(x+2) = 21$

10 mins:

For each equation, try to solve the equation using each method (dividing each side first, or applying the distributive property first). Some equations are easier to solve by one method than the other. When that is the case, stop doing the harder method and write down the reason you stopped.

Divide first?
or
Distribute first?

1. $2{,}000(x - 0.03) = 6{,}000$

$x = 3.03$

2. $2(x + 1.25) = 3.5$

$x = 0.5$

3. $\frac{1}{4}(4 + x) = \frac{4}{3}$

$x = \frac{4}{3}$

4. $-10(x - 1.7) = -3$

$x = 2$

5. $5.4 = 0.3(x + 8)$

$x = 10$

• doing the same thing to each side of an equation keeps it balanced, even with negative numbers

• doing the same thing to each side of an equation keeps it balanced, even if you don't get closer to a solution

## Lesson 9 Summary

When we want to find a solution to an equation, sometimes we just think about what value in place of the variable would make the equation true. Sometimes we perform the same operation on each side (for example, subtract the same amount from each side). The balanced hangers helped us to understand that doing the same to each side of an equation keeps the equation true.

Since negative numbers are just numbers, then doing the same thing to each side of an equation works for negative numbers as well. Here are some examples of equations that have negative numbers and steps you could take to solve them.

Example:

$$\begin{aligned} 2(x-5) &= \text{-}6 \\ \tfrac{1}{2}\cdot 2(x-5) &= \tfrac{1}{2}\cdot(\text{-}6) && \text{multiply each side by } \tfrac{1}{2} \\ x-5 &= \text{-}3 \\ x-5+5 &= \text{-}3+5 && \text{add 5 to each side} \\ x &= 2 \end{aligned}$$

Example:

$$\begin{aligned} \text{-}2x + \text{-}5 &= 6 \\ \text{-}2x + \text{-}5 - \text{-}5 &= 6 - \text{-}5 && \text{subtract -5 from each side} \\ \text{-}2x &= 11 \\ \text{-}2x \div \text{-}2 &= 11 \div \text{-}2 && \text{divide each side by -2} \\ x &= \text{-}\tfrac{11}{2} \end{aligned}$$

Doing the same thing to each side maintains equality even if it is not helpful to solving for the unknown amount. For example, we could take the equation $\text{-}3x + 7 = \text{-}8$ and add -2 to each side:

$$\begin{aligned} \text{-}3x + 7 &= \text{-}8 \\ \text{-}3x + 7 + \text{-}2 &= \text{-}8 + \text{-}2 && \text{add -2 to each side} \\ \text{-}3x + 5 &= \text{-}10 \end{aligned}$$

If $\text{-}3x + 7 = \text{-}8$ is true then $\text{-}3x + 5 = \text{-}10$ is also true, but we are no closer to a solution than we were before adding -2. We can use moves that maintain equality to make new equations that all have the same solution. Helpful combinations of moves will eventually lead to an equation like $x = 5$, which gives the solution to the original equation (and every equation we wrote in the process of solving).

NAME DATE PERIOD

## Lesson 10 Summary

Equations can be solved in many ways. In this lesson, we focused on equations with a specific structure, and two specific ways to solve them.

Suppose we are trying to solve the equation $\frac{4}{5}(x+27)=16$. Two useful approaches are:

- divide each side by $\frac{4}{5}$
- apply the distributive property

What kinds of things to look for to decide which approach is better:
• powers of 10 • operations resulting in whole numbers
• moves to eliminate fractions

In order to decide which approach is better, we can look at the numbers and think about which would be easier to compute. We notice that $\frac{4}{5} \cdot 27$ will be hard, because 27 isn't divisible by 5. But $16 \div \frac{4}{5}$ gives us $16 \cdot \frac{5}{4}$, and 16 is divisible by 4. Dividing each side by $\frac{4}{5}$ gives:

$$\begin{aligned}\frac{4}{5}(x+27) &= 16\\ \frac{5}{4} \cdot \frac{4}{5}(x+27) &= 16 \cdot \frac{5}{4}\\ x+27 &= 20\\ x &= \text{-}7\end{aligned}$$

Sometimes the calculations are simpler if we first use the distributive property. Let's look at the equation $100(x+0.06)=21$. If we first divide each side by 100, we get $\frac{21}{100}$ or 0.21 on the right side of the equation. But if we use the distributive property first, we get an equation that only contains whole numbers.

$$\begin{aligned}100(x+0.06) &= 21\\ 100x+6 &= 21\\ 100x &= 15\\ x &= \frac{15}{100}\end{aligned}$$

How can we check if our answer is correct?

→ substitute answer for the variable & evaluate to see if the equation is true