LESSON 10: Solving Linear Equations with One Variable

[Objective]
The student will utilize the distributive property and combine like terms in order to solve multi-step equations in mathematical and real world situations.

[Prerequisite Skills]
Solving two-step equations with one variable

[Materials]
Student pages **S119-S133**
Algebra tiles
Index cards or sticky notes (if needed)

[Essential Questions]
1. Explain how to identify like terms in an equation.
2. Why is combining like terms an essential part of solving an equation? Justify your answer.
3. How can the distributive property be used to solve equations? Defend your thinking.

[Words For Word Wall]
coefficients, constants, distributive property, like terms, variable, expression

[Grouping]
Cooperative Pairs (CP), Whole Group (WG), Individual (I)
*For Cooperative Pairs (CP) activities, assign the roles of Partner A or Partner B to students. This allows each student to be responsible for designated tasks within the lesson.

[Levels of Teacher Support]
Modeling (M), Guided Practice (GP), Independent Practice (IP)

[Multiple Representations]
SOLVE, Verbal Description, Pictorial Representation, Concrete Representation, Graphic Organizer, Algebraic Formula

[Warm-Up] (IP, WG) S119 (Answers on T259.)
Have students turn to S119 in their books to begin the Warm-Up. Students will solve two-step equations. Monitor students to see if any of them need help during the Warm-Up. After students have completed the Warm-Up, review the solutions as a group. **{Graphic Organizer, Algebraic Formula}**

[Homework]
Take time to go over the homework from the previous night.

[Lesson] [1 – 2 Days (1 day = 80 minutes) – M, GP, WG, CP, IP]

SOLVE Problem (WG, GP) S120 (Answers on T260.)

Have students turn to S120 in their books. The first problem is a SOLVE problem. You are only going to complete the S step with students at this point. Tell students that during the lesson they will learn how to solve linear equations with one variable by combining like terms, applying the distributive property and solving for the square root. They will use this knowledge to complete this SOLVE problem at the end of the lesson. **{SOLVE, Verbal Description, Graphic Organizer}**

Exploring Like Terms (M, GP, IP, CP, WG) S121, S122 (Answers on T261, T262.)

M, GP, CP, WG: Have students turn to S121 in their books. Students will explore simplifying like terms using concrete, pictorial and abstract representations. Pass out algebra tiles to student pairs. Review the value of the algebra tiles as needed. Assign the roles of Partner A and Partner B. **{Concrete Representation, Pictorial Representation, Graphic Organizer, Algebraic Formula}**

MODELING

Exploring Like Terms

Step 1: Direct students' attention to the top of S121.

- Have student pairs look at the list of terms and discuss what they notice about how the terms are alike and different. (Answers may vary but can include: **variables**, variables with **coefficients**, **constants**.)
- Have students make predictions about how the terms could be combined and encourage them to share their ideas and post them to revisit after the activity.

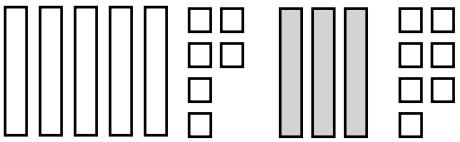
Step 2: Have students look at the **expression** in Problem 1.

- Partner A, what does the variable represent? (The variable represents an unknown value that makes the statement true.)
- Partner B, when using algebra tiles, what do we use to represent the variable or the *x*-value? (long yellow tiles for positive variables or long red tiles for negative variables)
- Partner A, when using algebra tiles, what do we use to represent the constant or the number value? (yellow unit tiles for positive values and red unit tiles for negative values)

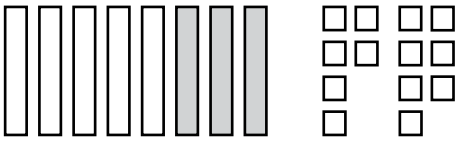
Step 3: Have student pairs discuss how they can represent the expression in Problem 1 using the algebra tiles.

- Partner A, explain how we can represent the expression. (5 long yellow *x*-tiles, 6 yellow unit tiles, 3 long red *x*-tiles, 7 yellow unit tiles) Have students work together to place these tiles on the workspace.

- Partner B, what do you notice about our expression? (We have several long *x*-tiles and several unit tiles and we have more than one color.)



- Partner A, how do you think we can simplify the expression? Explain your thinking. (Because we are adding, we can push together the tiles that are alike or combine all of the tiles that are the same shape.)
- Partner B, what is the name for tiles that have the same shape? (like terms)
- Have students move the tiles so that all of the same-shaped tiles are together.

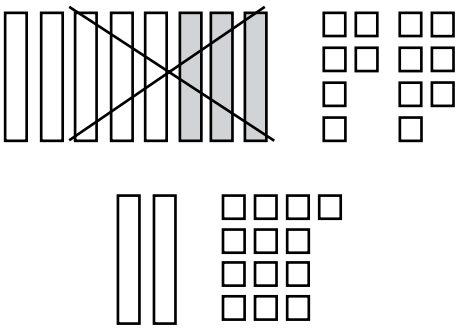


Step 4: Partner A, are all the *x*-tiles the same color? (No.) Explain what we can do when the tiles are two different colors? (Cancel any zero pairs by removing one red and one yellow tile until only one color is left.)

- Partner B, how many zero pairs should we take away from the variable tiles? (3 pairs) Have students physically remove the tiles from the workspace.
- Partner A, how many variable tiles are left? (2 yellow variable tiles, or 2*x*)

Step 5: Partner B, are all of the unit tiles the same color? (Yes, they are all yellow)

- Partner A, how many unit tiles are there in all? (13 yellow unit tiles)



- What is the expression that represents the remaining tiles? ($2x + 13$)
- Partner B, can we say that this expression is now simplified? Justify your answer. (The expression is simplified because there are no more like terms that can be combined.)

Step 6: Explain to students that the left side of the box will be used to represent the expression pictorially. Have students transfer the steps from the concrete model into the representation pictorially.

- Partner A, what was the first step we did to simplify? (We represented the expression with 5 yellow variable tiles, 6 yellow unit tiles, 3 red variable tiles and 7 more yellow unit tiles.) Have students draw this representation.
- Partner B, what was the next step? (We combined all of the tiles that are the same size and identified whether or not they were all one color.) Have students draw the sorting of the tiles.
- Partner A, what was the last step? (We canceled zero pairs of the variable tiles.) Have students cross out zero pairs on the pictorial representation and draw the final representation of the tiles that are left over.
- What is our simplified expression? (2 *x*-tiles and 13 unit tiles or $2x + 13$)

Step 7: Direct students' attention to the top right box of the table on S121.

- Partner B, what two types of terms did we combine when simplifying? (terms with a variable, *x*, and terms that were only numbers, or constants)
- Creating a chart is one strategy to group terms and be sure that you have not missed any terms.
- What are the labels for the chart? ("*x*" in the top left heading and "Constants" as the top right heading)

Step 8: Have students go back to the original expression for Problem 1.

- Partner A, identify the first term. ($5x$) Is this a term that contains the variable "*x*" or is it a constant? (It contains "*x*".) In what column should we place the $5x$? (variable column) Record.
- Partner B, what is the next term? (+6) Which category will this term fall under? (It is a constant.) In what column should we place the 6? (constant column) Record. What is the sign of the 6? (positive)
- Be sure that students copy the sign when they list the terms in the chart.
- Partner A, what is the next term? ($^{-}3x$) In what column should we place the $^{-}3x$? (variable or *x* column) Record.

- Partner B, what is the last term? (+7) Which category will this term fall under? (It is a constant.) In what column should we place the 7? (constant column) Record. What is the sign of the 7? (positive)

Step 9: Have students look at the terms in the *x* or variable column.

- Partner A, can we combine the like terms? (Yes) What is $5x - 3x$? ($2x$) Record at the bottom of the column.
- Partner B, can we combine the constants? (Yes) What is (+6) + (+7)? (+13) Record at the bottom of the column.
- What do you notice about the simplified columns? (The total at the bottom of the column represents the simplified expression we found earlier using the algebra tiles, $2x + 13$.)

Step 10: Direct students' attention to the box below the variable/constant chart.

- Explain to students that the bottom right box will be used for an abstract method of simplifying. Begin by having students copy the original expression into this box.
- Partner A, what was the next step pictorially to simplify? (We combined all of the like terms by grouping them together.) Have students rewrite the expression so that terms with the variable are first and the constants are second.

$$5x + 6 - 3x + 7$$
$$5x - 3x + 6 + 7$$

- Partner B, what do you notice about the operation between $5x$ and $3x$? (It is subtraction.) What was the next step when we represented the expression pictorially? (We canceled zero pairs, which subtracted $3x$ from the $5x$.)
- Partner A, what was left over after we took away zero pairs? ($2x$)
- Partner B, what is left if we subtract $5x - 3x$? ($2x$)
- Have student pairs discuss what process we used for combining like terms. (Add or subtract the coefficients, depending on if the operation is addition or subtraction between the terms.)
- Partner A, what is the last step? (Add the constants together: 6 + 7 = 13)
- What is the final simplified expression? ($2x + 13$) Record.

IP, CP, WG: Have students complete Questions 2–4 on S121 and S122. They will simplify the expressions given by pictorially representing the tiles. Have students discuss and review together, being sure that both partners record in the organizer. Review the models for the pictorial representations and then have students complete the rest of the graphic organizer with partners. Review the answers as a whole group. Note: Students may use the algebra tiles as needed. **{Concrete Representation, Pictorial Representation, Graphic Organizer, Algebraic Formula}**

**Conclusions: After reviewing the graphic organizers on S121 and S122, have student pairs discuss the three bullets on the bottom of S122.

- The expressions we worked with had several terms. How were we able to simplify them? (combining like terms) Record.
- Let's go back and look at our list of original terms. Can any of the terms be combined? (Yes.) Record.
- Combine the terms with your partner. (10a, 25, 2b, 4x) Record.

$6a$ $\quad 7 \quad$ $4b$ $\quad x \quad$ $18 \quad$ $4a \quad$ $3x \quad -2b$

- **Think about this:** If we added the term $3x^2$ to the list, could we combine it with the other x-terms? (No.) Record. Explain your thinking. (When we combine like terms, the variable must have the same exponent.) Record.

Solving Equations by Combining Like Terms

(M, GP, IP, CP, WG) S120, S123, S124 (Answers on T260, T263, T264.)

M, GP, CP, WG: Have students turn to S123 in their books. Students will apply what they have learned about combining like terms to solving equations. Be sure that students know their designation as Partner A and Partner B. **{Concrete Representation, Pictorial Representation, Verbal Description, Graphic Organizer}**

MODELING

Solving Equations by Combining Like Terms

Step 1: Students will use the balance scale on S120 to complete the concrete models of the equations.

- When we are solving equations, what are the two goals? (isolate the variable, balance the equation) Record.
- Have students take a look at first equation: $4x + 5 - 3x - 3 = 4$.
- Have student pairs discuss what makes up this equation. (Two expressions are set equal to each other to create an equation.)
- Partner B, what did you learn about the terms in an expression in the previously completed activity? Defend your thinking. (We learned that we can look for **like terms** to simplify the expression.)
- Partner A, what is the first expression? ($4x + 5 - 3x - 3$)
- Partner B, how can we represent this expression using tiles? (4 yellow x-tiles, 5 yellow unit tiles, 3 red x-tiles, and 3 red unit tiles)
- Have students use tiles to represent this on the left side of the balance scale.
- Partner B, what is the expression on the other side of the equal sign? (4)
- Partner A, explain how we can represent the 4 using the unit tiles. (4 yellow unit tiles) Have students place these tiles on the right side of the balance scale.

Step 2: Have student pairs now sort the like tiles, placing the x-tiles together and the unit tiles together.

- Partner A, looking at the expression on the left, is it possible to simplify the expression? Justify your answer. (Yes, we can combine like terms by canceling zero pairs.)
- Partner B, do we have zero pairs for the x-tiles? (Yes, three zero pairs) Have students take away these zero pairs.
- Partner A, do we have zero pairs for the unit tiles? (Yes, three zero pairs) Have students take away the additional zero pairs.
- Partner B, can we simplify the expression on the right side of the equation? (No)
- Partner A, what is the simplified equation now? ($x + 2 = 4$)

Step 3: Have student pairs determine if the expression on either side of the equal sign can be simplified any further? (No, because there are no like terms.)

- How can we describe the equation we have now? (a one-step equation)
- What is the goal at this point? (Our goal after combining like terms is to solve for the variable, x, by isolating it.)

- Partner A, how can we isolate the variable? (We can take away 2 yellow unit tiles from each side.) Have students take away the 2 unit tiles.
- Partner B, what is remaining on our balance scale? ($x = 2$)

Step 4: Have students go back to page S123 where they will create a pictorial representation of what they just modeled using the algebra tiles.

- Partner A, what was the first step? (We represented the equation with 4 yellow variable tiles, 5 yellow unit tiles, 3 red variable tiles and 3 red unit tiles on one side of the equal sign and 4 yellow unit tiles on the right side of the equal sign.) Have students draw this representation.
- Partner B, what was the second step? (We combined all of the tiles that are the same size and identified whether or not they were all in one color.) Have students draw the sorting of the tiles.
- Partner A, what was the next step? (We canceled zero pairs of the variable tiles.) Have students cross out zero pairs on the pictorial representation and draw the final representation of the tiles that are left over on the left side of the equation.
- Partner B, are there any like terms to be combined or zero pairs on the right side of the equation? (No)

Step 5: Explain what your picture now looks like after we simplify. (1 yellow variable tile and 2 yellow unit tiles on the left side of the equal sign; four yellow unit tiles on the right side of the equal sign)

- What tile represents our variable? (the long yellow tile)
- Partner A, explain how we can isolate that tile. (Cross out the two unit tiles to represent subtraction.)
- Have partners discuss the next step. (We need to balance the equation.)
- Partner B, explain how to balance the equation. (Cross out two yellow unit tiles on the right side of the equation to model subtraction.)

Step 6: What is the solution to our equation? (1 yellow variable tile is equal to two yellow unit tiles or $x = 2$.)

Step 7: Direct students' attention to the ABSTRACT box for Equation 1 on S123.

- Have students begin by copying the original equation.
- Partner A, explain the first step that we completed with the tiles. (We combined like terms by grouping the tiles together.)
- Partner B, what are the like terms on the left side of the equation? ($4x$ and $^{-}3x$, as well as $+5$ and $^{-}3$) Record.
- Partner A, what is the simplified form of the terms with variables? ($4x - 3x = x$)

- Partner B, what is the simplified form of the constant terms? ($^{+}5 - 3 = {}^{+}2$)
- Partner A, what is the simplified form of the left expression? ($x + 2$) Record.
- Partner B, can we simplify the right expression by combining like terms? (No)
- Partner A, what was the last step? (To isolate the variable, we took away two yellow unit tiles from each side.)
- Partner B, how do we represent this abstractly? (We subtract 2 from each side of the equation.)
- Why do we need to subtract the 2 from both sides of the equation? (to keep it balanced)
- Partner A, what is the final solution to the equation? ($x = 2$)

***Teacher Note:** Remind students they can use an organizational chart like on S121 and S122, as needed, when solving an equation. Remind students that equations are two expressions and throughout the solving process, we should be constantly asking if the expression can be simplified before we move forward. Students can easily create a t-chart to simplify the left expression in the beginning and then use the simplified expression to move forward with solving.

Step 8: Direct students' attention to the CHECK box for Equation 1 on S123.

- Partner B, justify your solution. (We can substitute the value of 2 into the original equation each time we see an x and simplify.)
- Partner A, if we simplify the left side of the equation by substituting 2, what is the result of the left expression? (The left side simplifies to 4.)
- Partner B, does this equal the right expression? (Yes, they are both 4, so our solution is correct.)

Step 9: Direct students' attention to Equation 2 on S123.

- Model this equation for students, using similar questioning for the concrete, pictorial and abstract models in Steps 1 – 8.

IP, CP, WG: Have students turn to S124. Have students work together to create the concrete, pictorial and abstract representations of the equations for Questions 3 and 4. Have students discuss and review their solutions together, being sure that both partners record in the organizer. When students have completed the equations, review the solutions as a group, being sure that students understand all representations. **{Concrete Representation, Pictorial Representation, Verbal Description, Graphic Organizer, Algebraic Formula}**

Solving Equations with the Distributive Property

(M, GP, IP, CP, WG) S120, S125, S126, S127, S128
(Answers on T260, T265, T266, T267, T268.)

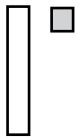
M, GP, CP, WG: Have students turn to S125 in their books. Using the algebra tiles, students will continue solving multi-step equations by applying the distributive property. Students will review the distributive property with expressions and then move to solving equations. Be sure students know their designation as Partner A or Partner B. **{Concrete Representation, Pictorial Representation, Verbal Description, Graphic Organizer, Algebraic Formula}**

MODELING

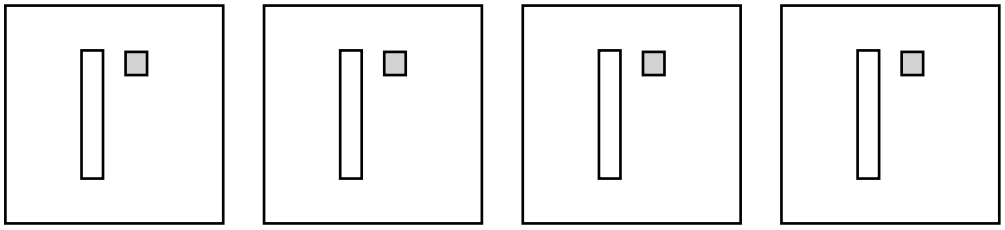
Solving Equations with the Distributive Property

Step 1: Have students look at the expressions in Boxes A – C.

- Partner A, what do you notice about the expressions for A, B, and C? (They each have a portion of the expression in parentheses.)
- Have students take out their algebra tiles.
- If we look at Expression A, we can assign groups and items. Ask students to explain what $4(x - 1)$ means in terms of groups and items. (We can see "4" as the number of groups and "$(x - 1)$" as the number of items in each group.) Have students create four groups of $(x - 1)$ items.
- Partner A, what does $(x - 1)$ look like in tiles? (It is one yellow x-tile and one red unit tile.)



- For simplicity, provide students with notecards or sticky notes to allow them to create four groups of the quantity, as displayed below.



- Partner A, how many x tiles do we have? (4 yellow x-tiles) How many unit tiles do we have? (4 red unit tiles)
- What is the simplified expression we can use to represent these four groups? $(4x - 4)$ Record.

Step 2: Direct students back to the first box on S125.

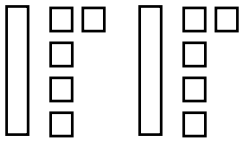
- Partner A, what does the **distributive property** tell us to do? (It takes the number or variable on the outside of the parentheses and multiplies it by every term on the inside of the parentheses.)
- Partner B, for Expression A, how do we simplify using the distributive property? (4 times x minus 4 times 1: $4x - 4$) Record.
- Does this simplified expression match the one we found with the tiles? (Yes.)

***Teacher Note:** It may be helpful for students to draw arrows to each term inside of the parentheses to ensure they multiply each term on the inside by the term on the outside.

- Have students work in pairs to multiply Problem B and C and then review the solutions as a whole group.

Step 3: Direct students to the box at the bottom of S125.

- Partner A, what is the equation that we are solving? [$2(x + 5) = 4$]
- Partner B, what do you notice about this equation? (The left expression contains grouping symbols and requires us to apply the distributive property.)
- Let's begin by representing the equation with algebra tiles.
- Partner A, how can we represent $2(x + 5)$? (Create two groups of $x + 5$, which is one yellow x-tile and five yellow unit tiles.) Ask students to use tiles to represent two groups of $(x + 5)$ on the balance scale on S120.



- Partner B, do we need anything else to represent this equation? (Yes, we still need to model the right side of the equation, which is four, or four yellow unit tiles.) Have students represent this.

Step 4: Have students discuss the next step for solving the equation. (Combine the like terms.)

- Partner A, what like terms can we combine? (We can combine the two yellow x-tiles on the left side of the equation. We can also combine the two sets of five yellow unit tiles also on the left side of the equation.) Have students combine these.
- Partner B, are all of our x-tiles in one color? (Yes. They are all yellow.) Are all of the unit tiles in one color? (Yes. They are all yellow.)
- Partner A, what is the next step in solving? (Continue to isolate the variable, by subtracting 10 yellow tiles from each side of the equation or we can add 10 red tiles to each side of the equation to cross out zero pairs.)

***Teacher Note:** Students will not be able to subtract 10 yellow tiles without creating the possibility using zero pairs.

- Partner B, what remains on the left side after we cancel zero pairs? (two yellow x-tiles) Partner A, what remains on the right side? (6 red unit tiles)
- Partner A, what is the last step? (Divide both sides into two groups by divvying the red unit tiles on the right into two groups.)
- Partner B, how many red tiles are in each group? (3 red tiles)
- Partner A, what is the value of x? ($x = ^{-}3$)

Step 5: Have students go back to page S125 where they will create a pictorial representation of what they just modeled using the algebra tiles.

- Partner A, what was the first step? (We represented the equation with 2 groups of x plus 5 items on the left side of the equation and a group of 4 units on the right side of the equation.) Have students draw this representation.
- Partner B, what was the second step? (We combined all of the tiles that are the same size and identified whether or not they were all in one color.) Have students draw the sorting of the tiles.
- Partner A, what was the next step? (In order to subtract 10 yellow unit tiles from both sides, we had to create the possibility with zero pairs.)

***Teacher Note:** In Equation 1, the pictorial representation shows adding 10 red unit tiles to each side because there would not be enough yellow tiles to subtract 10 from each side. We would need to create zero pairs to do this. You can model both strategies, but be sure that students understand that their abstract equation must be the same as the pictorial representation.

- Partner B, what is the solution to our equation at this point? (2 yellow x-tiles are equal to 6 red unit tiles.)
- Partner A, what is the last step? (Isolate the variable by dividing the two x-tiles into two groups and then dividing the six red unit tiles into two groups to determine the value of x.)
- What is our final pictorial solution? (1 yellow x-tile = 3 red unit tiles)

Step 6: Direct students to the box labeled "ABSTRACT" on the bottom of S125.

- Have students copy the original equation [$2(x + 5) = 4$].
- Partner A, what is the first step to solve this equation? (Use the distributive property to simplify the left side of the equation.) Have students complete the distributive property.
- Partner B, what is the simplified left side after the distributive property? ($2x + 10$)

- Partner A, what is the next step? (We can subtract ten from each side or add negative ten to each side.)

***Teacher Note:** Remember that this should match the pictorial representation provided. In the case of the solution provided, students should add a negative ten to each side.

- Partner B, what is the last step? (Divide each side by 2, so the value of x is $^{-}3$.)
- Partner A, how can we check this solution? (Substitute $^{-}3$ into the original equation.)
- What does the left side simplify to when we substitute $^{-}3$? (4) Record.
- Partner B, does the check create a true statement? (Yes, our solution is correct.)

Step 7: Work with students to solve the equation on S126 since they will need to apply the distributive property and work with a variable on both sides.

Step 8: Next have students work with their partners to solve Problem 3 on S127. Students can use the algebra tiles and pictorial representations as needed. Review the answers a whole group.

Step 9: Direct students to S128.

- Students will apply the skills they have learned in this lesson to solving equations with the distributive property and combining like terms.
- Model the first equation, reviewing the steps as needed.

IP, CP, WG: Have students solve the equations for Problems 2 – 4. At this point, students should be solving the equations abstractly. Remind students that they can use the t-chart to help organize the like terms, if needed. Review the solutions and be sure students understand how to approach each equation and follow through with solving and checking the solutions. **{Verbal Description, Table, Graphic Organizer, Algebraic Formula}**

Solving Equations with Square Roots with Positive Solutions

(M, GP, IP, CP, WG) S129, S130 (Answers on T269, T270.)

M, GP, CP, WG: Have students turn to S129 in their books. Students will use a concrete and pictorial representation to model solving square root equations with positive solutions. Be sure students know their designation as Partner A or Partner B. **{Concrete Representation, Pictorial Representation, Verbal Description, Graphic Organizer, Algebraic Formula}**

MODELING

Solving Equations with Square Roots with Positive Solutions

Step 1: Have students determine the positive value for the square root of the three expressions.
- Partner A, explain how we can find the square root of any number. (We determine what number times itself would equal the square.) Record.
- Have student pairs determine the side length of the square for the three examples and go over the solutions.

Step 2: Have student pairs make a square using 9 algebra tiles.
- Partner B, what must be true about the sides of the square? (They must be equal.)
- Have pairs create a picture of what they modeled with the tiles.
- Partner A, what is the length of each side of the square? (3 units)
- What is the square root of 9? (3) Explain your thinking. [The square that we make with 9 units has a side length of 3. ($3 \times 3 = 9$)]

Step 3: Have student pairs look at the equation in Problem 1. Have pairs discuss how this equation is alike and how it is different than the other equations they have solved before. (has a variable, but the variable has an exponent)
- Partner B, when solving equations, what are the two goals? (Isolate the variable and balance the equation.)
- Partner A, what is the opposite of squaring a number? (find the square root)
- Partner B, what is the square root of x^2? (x) Explain. ($x \bullet x = x^2$) Record.
- Partner A, what is the solution to the equation? ($x = 3$) Record.

Step 4: Partner B, how can we check the solution? (by substituting in the value of 3 for x)
- Partner A, what is 3 squared? (9) Record.
- Partner B, what is the square root of 9? (3) Is our equation balanced? (Yes)

Step 5: Model Problem 2 and guide students through solving the equation.
- Have students turn to S130 and complete Problems 1 – 4 with a partner. Review the answers as a whole group.

Step 6: Have student look at the equation $x^2 = \frac{9}{16}$
- Partner B, how can we isolate the variable? (find the square root of x^2) Record.
- Partner A, what is the square root of x^2 (x) Record. Explain how you determined the square root of x^2. (The square root of x^2 is x because $x \bullet x = x^2$.) Record.
- Have students determine the next step.(Find the square root of $\frac{9}{16}$.) Record.

Step 7: Partner A, what is the square root of $\frac{9}{16}$? ($\frac{3}{4}$) Record. Explain how you determined the square root of $\frac{9}{16}$. (Find the square root of the numerator and the denominator. $\frac{\sqrt{9}}{\sqrt{16}} = \frac{3}{4}$) Record.

- Have student pairs complete Problems 11 and 12 and review the solutions.

SOLVE Problem **(WG, GP) S131 (Answers on 271.)**

Remind students that the SOLVE problem is the same one from the beginning of the lesson. Complete the SOLVE problem with your students. Ask them for possible connections from the SOLVE problem to the lesson. (Students solved linear equations with one variable using the distributive property and combining like terms.) **{SOLVE, Verbal Description, Graphic Organizer, Algebraic Formula}**

If time permits... **(CP, IP) S132 (Answers on T272.)**

Have students solve the additional equations on S132.

[Closure]
To wrap up the lesson, go back to the essential questions and discuss them with students.

- Explain how to identify like terms in an equation. *(Like terms have the same variable raised to the same power, or do not have variables at all. For example: 2x and 3x, or 5 and 6)*
- Why is combining like terms an essential part of solving an equation? Justify your answer. *(The goal when solving an equation is to solve for a variable. If we cannot isolate the variable by combining like terms, we will not be able to reach the goal of identifying the value of the variable.)*
- How can the distributive property be used to solve equations? Defend your thinking. *(In cases where grouping symbols are used, a term on the outside of the grouping symbols is distributed to every term inside of the grouping symbols in order to simplify and solve for a variable.)*

[Homework] Assign S133 for homework. (Answers on T273.)

[Quiz Answers] T274
1. **C** 2. **B** 3. **C** 4. **C** 5. **B** 6. **A** 7. **B** 8. **B** 9. **B** 10. **D**

The quiz can be used at any time as extra homework or to see how students progress solving linear equations with one variable using the distributive property and combining like terms.

Here is the key to **S119**.

Warm–Up

Directions: Solve each of the two-step equations below.

1. $3x + 7 = 5$ $\boldsymbol{x = \frac{-2}{3}}$	**2.** $-x + 4 = 13$ $\boldsymbol{x = -9}$
3. $10x = 4x + 5$ $\boldsymbol{x = \frac{5}{6}}$	**4.** $7 - 2x = 5$ $\boldsymbol{x = 1}$
5. $-6x - 6 = 18$ $\boldsymbol{x = -4}$	**6.** $\frac{x}{3} + 9 = 12$ $\boldsymbol{x = 9}$

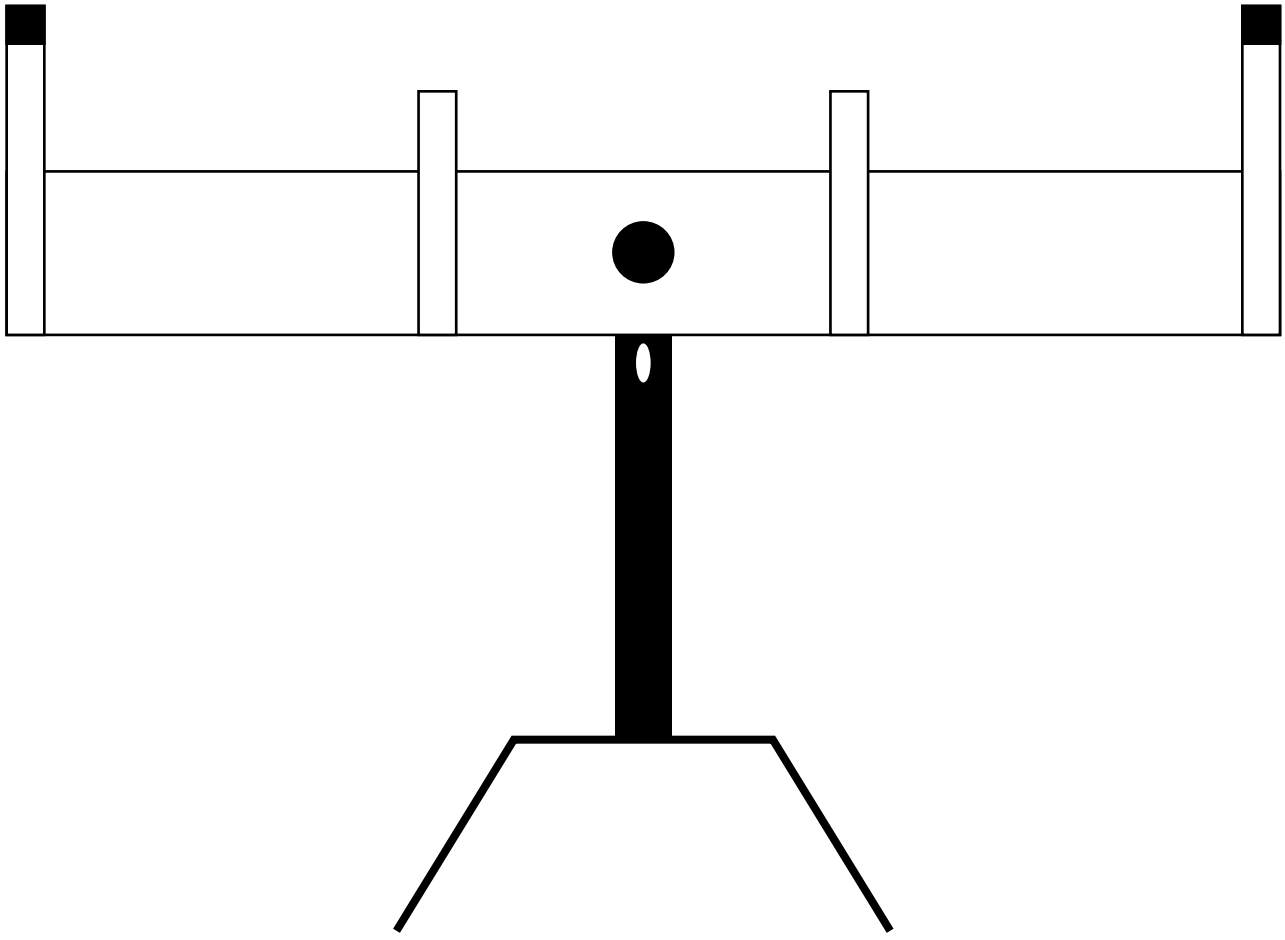
Here is the key to **S120**.

Directions: Complete the following SOLVE problem with your teacher. You will only complete the S step.

Matt is buying lunch for his family. There are five people in the family including Matt. The total bill for the lunch is $35 and the cost for each drink is $2.00. Matt keeps $20 in his wallet for emergencies. If each member has a sandwich that costs the same amount, how much is each sandwich?

S Underline the question.
This problem is asking me to find **the cost of one sandwich.**

Directions: Complete this page with your teacher and partner.



Here is the key to **S121**.

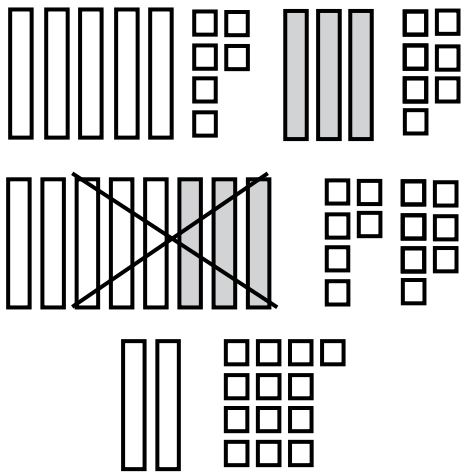
Directions: Complete this page with your teacher and partner.

Look at the list of terms below. Discuss with your partner the similarities and differences that you observe. **(Answers may vary but can include: variables, variables with coefficients, constants)**

$6a$ 7 $4b$ x 18 $4a$ $3x$ $^{-}2b$

Can the terms be simplified or combined in any way? Let's use our algebra tiles to explore how we can work with expressions that have different variables and constants.

1. $5x + 6 - 3x + 7$

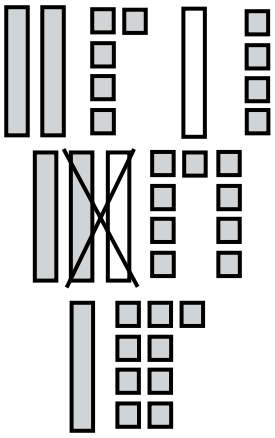


x	Constants
$5x$	**$+ 6$**
$- 3x$	**$+ 7$**
$2x$	**$+ 13$**

$2x + 13$

$5x + 6 - 3x + 7$
$5x - 3x + 6 + 7$
$2x + 13$

2. $^{-}2p - 5 + p - 4$



p	Constants
$^{-}2p$	**$- 5$**
p	**$- 4$**
$-p$	**$- 9$**

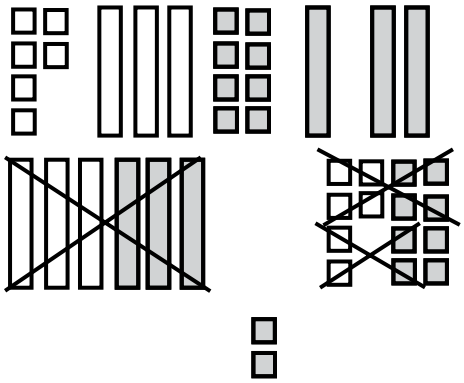
$-p - 9$

$^{-}2p - 5 + p - 4$
$^{-}2p + p - 5 - 4$
$^{-}p - 9$

Here is the key to **S122**.

Directions: Complete this page with your partner.

3. $6 + 3m - 8 - m - 2m$

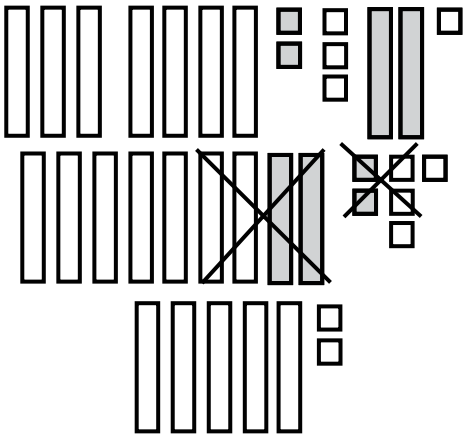


m	Constants
+ 3*m*	**6**
– *m*	**– 8**
– 2*m*	
0	**– 2**

$^{-}2$

$6 + 3m - 8 - m - 2m$
$3m - m - 2m + 6 - 8$
$^{-}2$

4. $3j + 4j - 2 + 3 - 2j + 1$



j	Constants
3*j*	**– 2**
+ 4*j*	**+ 3**
– 2*j*	**+ 1**
5*j*	**+ 2**

$5j + 2$

$3j + 4j - 2 + 3 - 2j + 1$
$3j + 4j - 2j - 2 + 3 + 1$
$5j + 2$

Conclusions:

- The expressions we worked with had several terms and we found that we could simplify them by **combining like terms.**

- Let's go back and look at our list of original terms. Can any of the terms be combined? **Yes**. Combine the terms with your partner. **10*a*, 25, 2*b*, 4*x***

$6a$ 7 $4b$ x 18 $4a$ $3x$ $^{-}2b$

- **Think about this:** If we added the term $3x^2$ to the list, could we combine it with the other x terms? **No.** Explain your thinking. **When we combine like terms, the variable must have the same exponent.**

Here is the key to **S123**.

Directions: Complete this page with your teacher and partner.

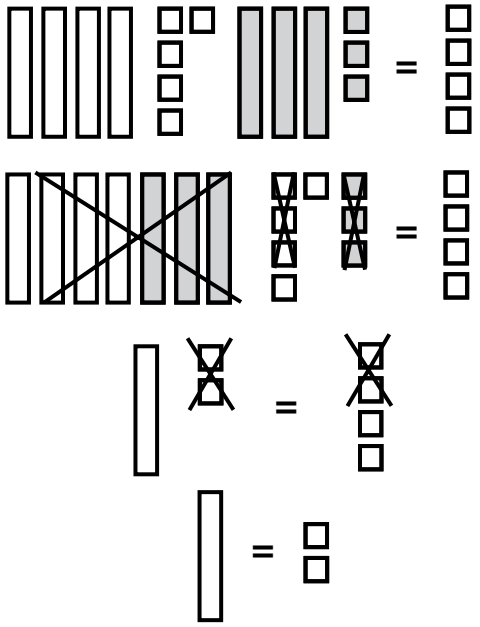
Let's apply what we have learned about combining like terms to solving equations.

When solving equations, what are the two goals?

- **Isolate the variable**
- **Balance the equation**

1. $4x + 5 - 3x - 3 = 4$

PICTORIAL:



ABSTRACT:

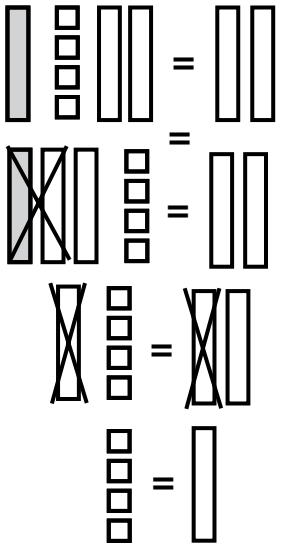
$$\begin{aligned} 4x + 5 - 3x - 3 &= 4 \\ 4x - 3x + 5 - 3 &= 4 \\ x + 2 &= 4 \\ -2 \quad &-2 \\ \hline x &= 2 \end{aligned}$$

CHECK:

$$\begin{aligned} 4x + 5 - 3x - 3 &= 4 \\ 4(2) + 5 - 3(2) - 3 &= 4 \\ 8 + 5 - 6 - 3 &= 4 \\ 13 - 6 - 3 &= 4 \\ 7 - 3 &= 4 \\ 4 &= 4 \end{aligned}$$

2. $^{-}x + 4 + 2x = 2x$

PICTORIAL:



ABSTRACT:

$$\begin{aligned} {}^{-}x + 4 + 2x &= 2x \\ {}^{-}x + 2x + 4 &= 2x \\ x + 4 &= 2x \\ -x \quad &-x \\ \hline 4 &= x \end{aligned}$$

CHECK:

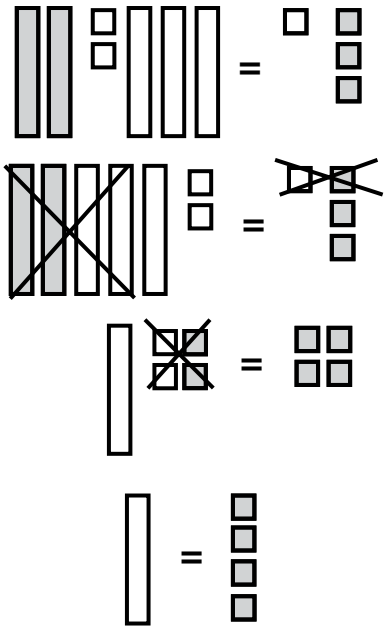
$$\begin{aligned} {}^{-}x + 4 + 2x &= 2x \\ {}^{-}(4) + 4 + 2(4) &= 2(4) \\ {}^{-}4 + 4 + 8 &= 8 \\ 0 + 8 &= 8 \\ 8 &= 8 \end{aligned}$$

Here is the key to **S124**.

Directions: Complete this page with your partner.

3. $^-2x + 2 + 3x = 1 + {}^-3$

PICTORIAL:



ABSTRACT:

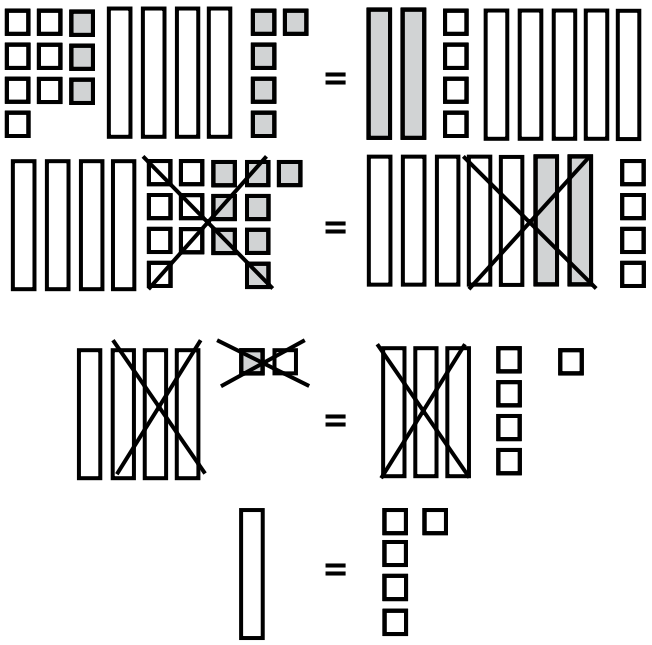
$$^-2x + 2 + 3x = 1 + {}^-3$$
$$^-2x + 3x + 2 = {}^-2$$
$$x + 2 = {}^-2$$
$$+ {}^-2 + {}^-2$$
$$x = {}^-4$$

CHECK:

$$^-2x + 2 + 3x = 1 + {}^-3$$
$$^-2(^-4) + 2 + 3(^-4) = 1 + {}^-3$$
$$8 + 2 - 12 = 1 - 3$$
$$10 - 12 = 1 - 3$$
$$^-2 = {}^-2$$

4. $7 - 3 + 4x - 5 = {}^-2x + 4 + 5x$

PICTORIAL:



ABSTRACT:

$$7 - 3 + 4x - 5 = {}^-2x + 4 + 5x$$
$$4x + 7 - 3 - 5 = {}^-2x + 5x + 4$$
$$4x - 1 = 3x + 4$$
$$- 3x \quad - 3x$$
$$x - 1 = 4$$
$$+ 1 \; +1$$
$$x = 5$$

CHECK:

$$7 - 3 + 4x - 5 = {}^-2x + 4 + 5x$$
$$7 - 3 + 4(5) - 5 = {}^-2(5) + 4 + 5(5)$$
$$7 - 3 + 20 - 5 = {}^-10 + 4 + 25$$
$$4 + 20 - 5 = {}^-6 + 25$$
$$24 - 5 = 19$$
$$19 = 19$$

Here is the key to **S125**.

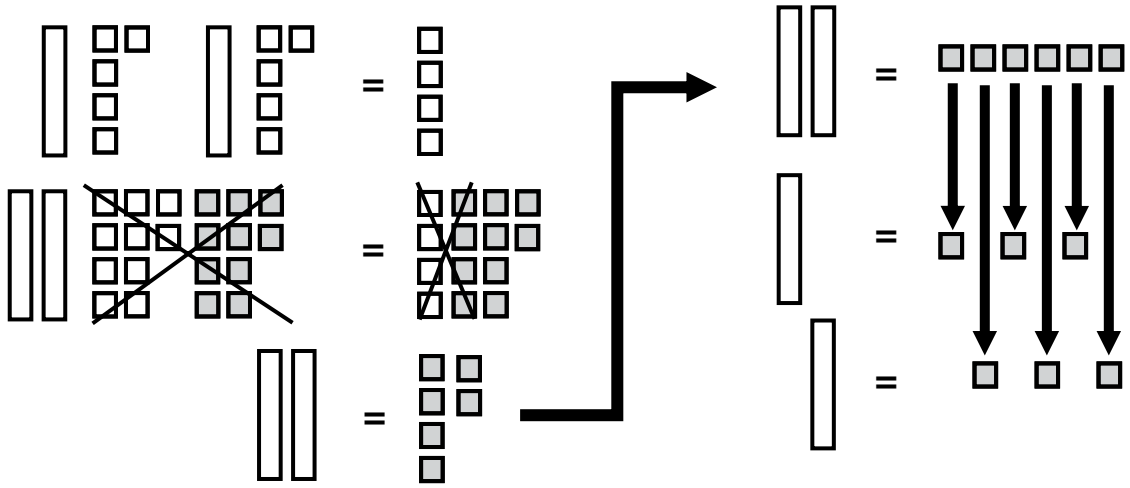
Directions: Complete this page with your teacher and partner.

A. $4(x - 1)$	**B.** $-7(2 + x)$	**C.** $6(x + 8) - 3$
$\mathbf{4x - 4}$	$\mathbf{-14 - 7x}$	$\mathbf{6x + 48 - 3}$ $\mathbf{6x + 45}$

How did you simplify the expressions above? **We used the distributive property to distribute the constant on the outside of the parentheses to each term on the inside of the parentheses.**

1. $2(x + 5) = 4$

PICTORIAL:



ABSTRACT:

$$\begin{array}{r} \mathbf{2(x + 5) = 4} \\ \mathbf{2x + 10 = 4} \\ \hline \mathbf{+^{-}10 \quad +^{-}10} \\ \mathbf{\frac{2x}{2} = \frac{^{-}6}{2}} \\ \mathbf{x = ^{-}3} \end{array}$$

CHECK:

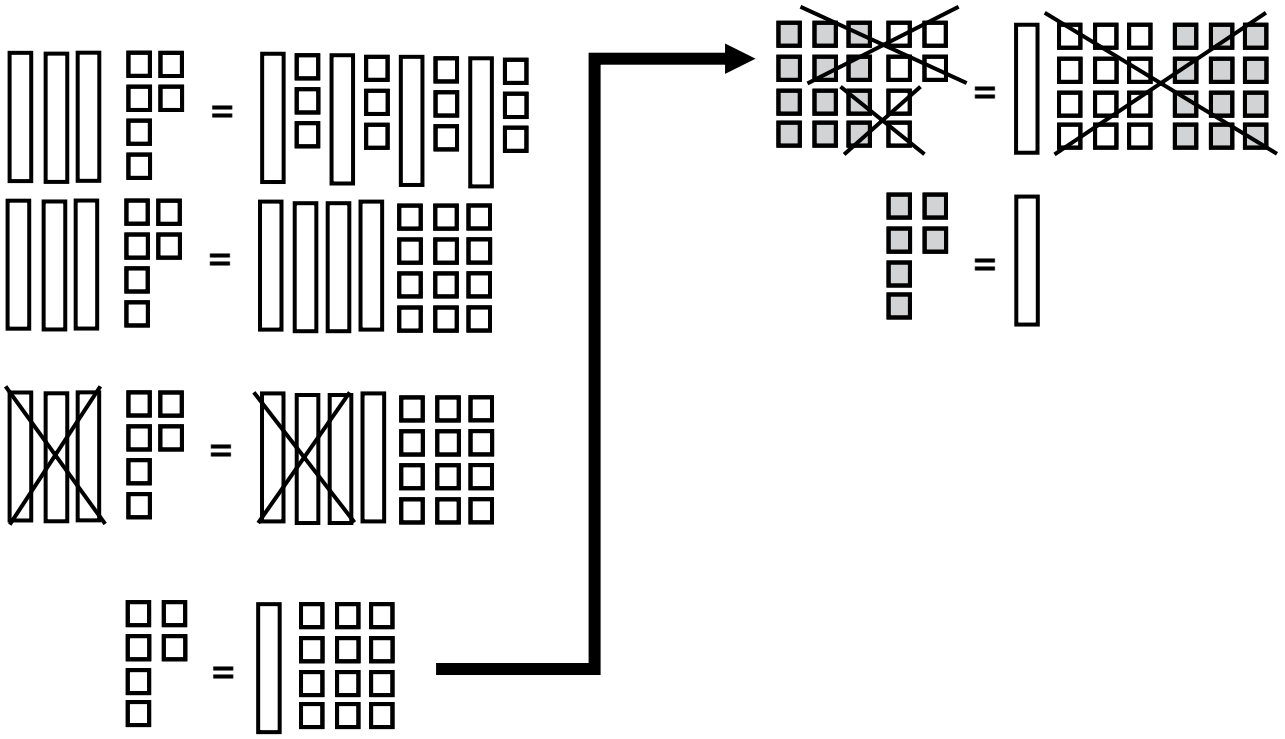
$$\begin{aligned} \mathbf{2(x + 5)} &= \mathbf{4} \\ \mathbf{2(^{-}3 + 5)} &= \mathbf{4} \\ \mathbf{2(2)} &= \mathbf{4} \\ \mathbf{4} &= \mathbf{4} \end{aligned}$$

Here is the key to **S126**.

Directions: Complete this page with your teacher and partner.

2. $3x + 6 = 4(x + 3)$

PICTORIAL:



ABSTRACT:

$$3x + 6 = 4(x + 3)$$
$$3x + 6 = 4x + 12$$
$$-3x \quad -3x$$
$$6 = x + 12$$
$$+\,{}^{-}12 \quad +\,{}^{-}12$$
$${}^{-}6 = x$$

CHECK:

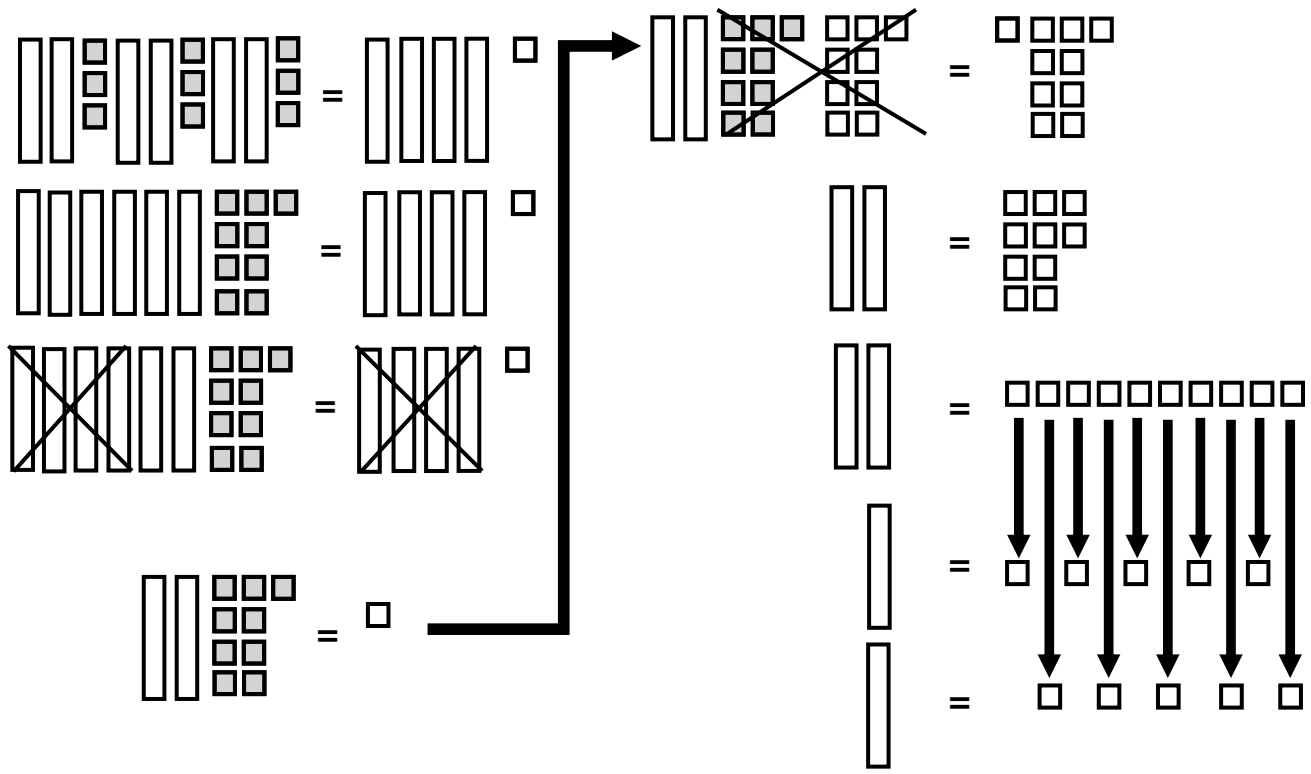
$$3x + 6 = 4(x + 3)$$
$$3({}^{-}6) + 6 = 4({}^{-}6 + 3)$$
$${}^{-}18 + 6 = 4({}^{-}3)$$
$${}^{-}12 = {}^{-}12$$

Here is the key to **S127**.

Directions: Complete this page with your teacher and partner.

3. $3(2x - 3) = 4x + 1$

PICTORIAL:



ABSTRACT:

$$3(2x - 3) = 4x + 1$$
$$6x - 9 = 4x + 1$$
$$-4x \quad -4x$$
$$2x - 9 = 1$$
$$+9 \quad +9$$
$$\frac{2x}{2} = \frac{10}{2}$$
$$x = 5$$

CHECK:

$$3(2x - 3) = 4x + 1$$
$$3(2[5] - 3) = 4(5) + 1$$
$$3(10 - 3) = 20 + 1$$
$$3(7) = 21$$
$$21 = 21$$

Here is the key to **S128**.

Directions: Complete this page below with your teacher and partner.

1. $-x + 3 = 2(3 - 2x)$

$$-x + 3 = 2(3 - 2x)$$
$$-x + 3 = 6 - 4x$$
$$+4x \qquad +4x$$
$$3x + 3 = 6$$
$$-3 \quad -3$$
$$\frac{3x}{3} = \frac{3}{3}$$
$$x = 1$$

Check:

$$-x + 3 = 2(3 - 2x)$$
$$-(1) + 3 = 2(3 - 2[1])$$
$$-1 + 3 = 2(3 - 2)$$
$$2 = 2(1)$$
$$2 = 2$$

2. $7x + 16 = 2(8x + 1) - 4$

$$7x + 16 = 2(8x + 1) - 4$$
$$7x + 16 = 16x + 2 - 4$$
$$7x + 16 = 16x - 2$$
$$-7x \qquad -7x$$
$$16 = 9x - 2$$
$$+2 \qquad +2$$
$$\frac{18}{9} = \frac{9x}{9}$$
$$2 = x$$

Check:

$$7x + 16 = 2(8x + 1) - 4$$
$$7(2) + 16 = 2(8[2] + 1) - 4$$
$$14 + 16 = 2(16 + 1) - 4$$
$$30 = 2(17) - 4$$
$$30 = 34 - 4$$
$$30 = 30$$

3. $4(x + 9) = -6x + 6$

$$4(x + 9) = -6x + 6$$
$$4x + 36 = -6x + 6$$
$$+6x \qquad +6x$$
$$10x + 36 = 6$$
$$-36 \quad -36$$
$$\frac{10x}{10} = \frac{-30}{10}$$
$$x = -3$$

Check:

$$4(x + 9) = -6x + 6$$
$$4([-3] + 9) = -6(-3) + 6$$
$$4(6) = 18 + 6$$
$$24 = 24$$

4. $3(4 - x) + 2 = 4(x + 3) + 2$

$$3(4 - x) + 2 = 4(x + 3) + 2$$
$$12 - 3x + 2 = 4x + 12 + 2$$
$$14 - 3x = 4x + 14$$
$$+3x \quad +3x$$
$$14 = 7x + 14$$
$$-14 \qquad -14$$
$$\frac{0}{7} = \frac{7x}{7}$$
$$0 = x$$

Check:

$$3(4 - x) + 2 = 4(x + 3) + 2$$
$$3(4 - [0]) + 2 = 4([0] + 3) + 2$$
$$3(4) + 2 = 4(3) + 2$$
$$12 + 2 = 12 + 2$$
$$14 = 14$$

Here is the key to **S129**.

Directions: Complete this page below with your teacher and partner.

Square Root Equations

What is the square root of the following expressions?

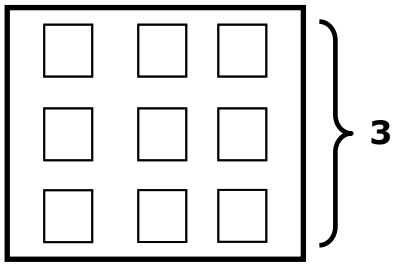
$\sqrt{64}$ = **8** $\sqrt{121}$ = **11** $\sqrt{169}$ = **13**

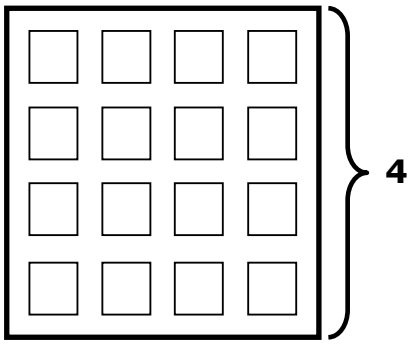
Explain how we can find the square root of any number. **We determine what number times itself would equal the square.**

If the area of a square is 64 units^2 then each side of the square is **8** units.

If the area of a square is 121 units^2 then each side of the square is **11** units.

If the area of a square is 169 units^2 then each side of the square is **13** units.

<table>
<tr><td colspan="2">1. $x^2 = 9$</td></tr>
<tr><td>PICTORIAL:
 
</td><td>ABSTRACT:
$\boldsymbol{x^2 = 9}$
$\boldsymbol{\sqrt{x^2} = \sqrt{9}}$
$\boldsymbol{x = 3}$

CHECK:
$\boldsymbol{x^2 = 9}$
$\boldsymbol{3^2 = 9}$
$\boldsymbol{9 = 9}$</td></tr>
<tr><td colspan="2">2. $x^2 = 16$</td></tr>
<tr><td>PICTORIAL:
 
</td><td>ABSTRACT:
$\boldsymbol{x^2 = 16}$
$\boldsymbol{\sqrt{x^2} = \sqrt{16}}$
$\boldsymbol{x = 4}$

CHECK:
$\boldsymbol{x^2 = 16}$
$\boldsymbol{4^2 = 16}$
$\boldsymbol{16 = 16}$</td></tr>
</table>

Here is the key to **S130**.

Directions: Complete this page with your teacher and partner.

1. $x^2 = 25$
$\boldsymbol{\sqrt{x^2} = \sqrt{25}}$
$\boldsymbol{x = 5}$

2. $x^2 = 36$
$\boldsymbol{\sqrt{x^2} = \sqrt{36}}$
$\boldsymbol{x = 6}$

3. $x^2 = 100$
$\boldsymbol{\sqrt{x^2} = \sqrt{100}}$
$\boldsymbol{x = 10}$

4. $x^2 = 81$
$\boldsymbol{\sqrt{x^2} = \sqrt{81}}$
$\boldsymbol{x = 9}$

Let's look at the following equation: $x^2 = \frac{9}{16}$

5. How can we isolate the variable? **Find the square root of x^2.**

6. What is the square root of x^2? $\boldsymbol{x}$

7. Explain how you determined the square root of x^2. **The square root of x^2 is x because $x \bullet x = x^2$.**

8. What is the next step? **Find the square root of $\frac{9}{16}$.**

9. What is the square root of $\frac{9}{16}$? $\boldsymbol{\frac{3}{4}}$

10. Explain how you determined the square root of $\frac{9}{16}$. **Find the square root of the numerator and the denominator.** $\boldsymbol{\frac{\sqrt{9}}{\sqrt{16}} = \frac{3}{4}}$

11. $x^2 = \frac{25}{49}$
$\boldsymbol{\sqrt{x^2} = \sqrt{\frac{25}{49}}}$
$\boldsymbol{x = \frac{\sqrt{25}}{\sqrt{49}}}$
$\boldsymbol{x = \frac{5}{9}}$

12. $x^2 = \frac{64}{169}$
$\boldsymbol{\sqrt{x^2} = \sqrt{\frac{64}{169}}}$
$\boldsymbol{x = \frac{\sqrt{64}}{\sqrt{169}}}$
$\boldsymbol{x = \frac{8}{13}}$

Here is the key to **S131**.

Directions: Complete the following SOLVE problem with your teacher.

~~Matt is buying lunch for his family.~~ | There are five people in the family, including Matt. | The total bill for the lunch is $35| and the cost for each drink is $2.00.| ~~Matt keeps $20 in his wallet for emergencies.~~ | If each member has a sandwich that costs the same amount, | how much is each sandwich?

S Underline the question.
This problem is asking me to find **the cost of one sandwich.**

O Identify the facts.
Eliminate the unnecessary facts.
List the necessary facts. **5 family members; $2 per drink; Total bill $35; *x* = cost per sandwich**

L Write in words what your plan of action will be. **Create an expression that adds the cost of a drink with the cost per sandwich to create the cost per person. Then, multiply this expression by the number of family members. Set this new expression equal to the total cost of the bill. Solve the equation.**
Choose an operation or operations. **Multiplication, subtraction, division**

V Estimate your answer. **About $5**
Carry out your plan.
Family Members (Sandwich Cost + Drink Cost) = Total Bill

$$5(x + 2) = 35$$
$$5x + 10 = 35$$
$$-10 \quad -10$$
$$\frac{5x}{5} = \frac{25}{5}$$
$$x = \$5 \text{ per sandwich}$$

CHECK: $5(x + 2) = 35$
$5([5] + 2) = 35$
$5(7) = 35$
$35 = 35$

E Does your answer make sense? (Compare your answer to the question.) **Yes, because we found the cost per sandwich.**
Is your answer reasonable? (Compare your answer to the estimate.) **Yes, because it matches our estimate of about $5.**
Is your answer accurate? (Check your work.) **Yes**
Write your answer in a complete sentence. **The cost of one sandwich is $5.**

Here is the key to **S132**.

Directions: Complete this page with your partner.

Simplify by combining like terms.

1. $5x + 3x - 4x + 5 - 7$ **$4x - 2$**	**2.** $^-2x + 3x - 4 + 8 - 2x$ **$^-x + 4$**

Solve the equations below.

3. $2x - 3x + 5 = 4x - 3$ **$x = \frac{8}{5}$**	**4.** $\frac{1}{4}x - 2x + 3 = x + 2 - 7$ **$x = \frac{32}{11}$**
5. $^-3x + 5 - 4x = 2x + 4 - 5x$ **$x = \frac{1}{4}$**	**6.** $^-10x + 5x - 3 = {}^-4x - x - x$ **$x = 3$**
7. $^-4(x + 5) = 3x - 4$ **$x = \frac{^-16}{7}$**	**8.** $5(^-x + 3) = 4(x + 7)$ **$x = \frac{^-13}{9}$**
9. $x^2 = 100$ **$x = 10$**	**10.** $x^2 = 225$ **$x = 15$**

Here is the key to **S133**.

Homework

Name _____ **Date** _____

Directions: Simplify by combining like terms.

1. $^-3 + 10 - 3x + 4x - 3$ **$x + 4$**	**2.** $4x + 3x - 5 - 2x\ ^-6$ **$5x - 11$**

Directions: Solve the equations below.

3. $^-3x + 5x - 3 - 3 = 4x + 5x$ **$x = \frac{^-6}{7}$**	**4.** $6x - 5 = 4x - {}^-5x + 9$ **$x = \frac{^-14}{3}$**
5. $4x + 12 - 2x = 26$ **$x = 7$**	**6.** $^-4x - x + 6x = 15$ **$x = 15$**
7. $3(x + 4) = 4(x - 5)$ **$x = 32$**	**8.** $4(x + 5) + 3x = {}^-2$ **$x = \frac{^-22}{7}$**
9. $x^2 = 49$ **$x = 7$**	**10.** $x^2 = 25$ **$x = 5$**

Name _____ Date _____

Quiz

1. Combining like terms of $8x - 7x + 5 - 9x + 3$, simplifies the expression to:
A. $^{-}8x - 8$
B. $8x - 8$
C. $^{-}8x + 8$
D. $8x + 8$

2. Combining like terms of $10x - 3 + 11 - 2x + 3x$, simplifies the expression to:
A. $11x + 14$
B. $11x + 8$
C. $9x + 8$
D. $9x + 14$

3. The solution to the equation $18 = 4x + 2 - 2x$ is:
A. $x = \frac{8}{3}$
B. $x = \frac{2}{9}$
C. $x = 8$
D. $x = 10$

4. The solution to the equation $8(x - 3) = 4x - 52$
A. $x = \frac{49}{4}$
B. $x = 13$
C. $x = {}^{-}7$
D. $x = 7$

5. The solution to the equation $x^2 = 400$ is:
A. $x = 10$
B. $x = 20$
C. $x = 40$
D. $x = 100$

6. The solution to the equation $2(x - 6) = 60$ is:
A. $x = 36$
B. $x = 33$
C. $x = 24$
D. $x = 21$

7. The solution to the equation $^{-}3(x - 4) = 2x + 4 - x$ is:
A. $x = {}^{-}2$
B. $x = 2$
C. $x = {}^{-}1$
D. $x = 1$

8. The solution to the equation $6x - 4x - 8 = 32$ is:
A. $x = 40$
B. $x = 20$
C. $x = 16$
D. $x = 4$

9. The solution to the equation $7(x - 4) = 3(x + 2) + 2$ is:
A. $x = \frac{5}{2}$
B. $x = 9$
C. $x = 3$
D. $x = {}^{-}1$

10. The solution to the equation $x^2 = 4$ is:
A. $x = 8$
B. $x = 4$
C. $x = 3$
D. $x = 2$