

Algebra I

Predicting Patterns & Examining Experiments

Unit 4: Twice the Change

Section 1: Comparing Apples to X's

Unit 4 covers student's first examination of systems of linear equations. First though, we must look at combining like terms and solving equations that have x on each side of the equation.

What are the dimensions of the room?

Evelyn is redoing the baseboard in a room. She measured the dimensions and the perimeter of the room came to 66 feet of baseboard. Now that she's at the store, she has forgotten the exact dimensions in order to cut the pieces at the store. She does remember that the room was 8 feet longer than it was wide. What are the dimensions of the room?

(Small group discussion) In this first problem, we will derive and solve a linear equation that requires us to combine like terms (on the same side of the equation). To write the equation, we will first use a table to see the pattern.

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width guess	length	perimeter	target	check?
7	$(7) + 8 = 15$	$2(7) + 2(15) = 44$	66	no

(Large group discussion) The table is started for students... the next slide contains another row that doesn't check

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width guess	length	perimeter	target	check?
7	$(7) + 8 = 15$	$2(7) + 2(15) = 44$	66	no
10	$(10) + 8 = 18$	$2(10) + 2(18) = 56$	66	no

(Large group discussion) The table is started for students... and one more row if necessary to get the pattern

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12	$(12) + 8 = 20$	$2(12) + 2(20) = 64$	66	no
12.5	$(12.5) + 8 = 20.5$	$2(12.5) + 2(20.5) = 66$	66	yes

(Large group discussion) The table is completed and we've found our answer. By noticing the slope (change in perimeter as I changed my guess), I tweaked my numbers to include decimals. The next slide contains the answer expressed verbally.

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12.5	$(12.5) + 8 = 20.5$	$2(12.5) + 2(20.5) = 66$	66	yes

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) The solution, but let us now look at the pattern in the table in order to write an equation.

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w	$(w) + 8$			

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) Unknown dimensions are noted.

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12.5	$(12.5) + 8 = 20.5$	$2(12.5) + 2(20.5) = 66$	66	yes
w	$(w) + 8$	$2(w) + 2(w+8)$	66	

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) perimeter expressed analytically and the target of 66.

What are the dimensions of the room?

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w	$(w) + 8$	$2(w) + 2(w+8) =$	66	YES!

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) Our goal is to solve for w so that the answer does check. We need to solve this equation

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baseboard. Now that she's at the store, she has forgotten the exact dimensions in order to cut the pieces at the store. She does remember that the room was 8 feet longer than it was wide.

$$2w + 2 \cdot (w + 8) = 66$$

$$2w + 2 \cdot w + 2 \cdot 8 = 66$$

$$2w + 2w + 16 = 66$$

12.5	$(12.5) + 8 = 20.5$	$2(12.5) + 2(20.5) = 66$	66	yes
w	$(w) + 8$	$2(w) + 2(w+8) =$	66	YES!

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) This may be a dilemma for students but a simple question such as “if you have two w’s and two more w’s, how many w’s do you have”. Or, you can justify the combining of like terms using the distributive property in reverse: $2w + 2w = (2 + 2) \cdot w$. All in all, this step is intuitive for students (until we bring in x^2 in later algebra).

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$$2w + 2 \cdot (w + 8) = 66$$

$$2w + 2 \cdot w + 2 \cdot 8 = 66$$

$$2w + 2w + 16 = 66$$

$$4w + 16 = 66$$

$$4w - 16 = 66 - 16$$

$$4w = 50$$

$$\frac{4w}{4} = \frac{50}{4}$$

$$w = 12.5$$

$$12w = 12.5 \rightarrow l = 20.5$$

width	length	perimeter	target	check?
7	$(7) + 8 = 15$	$2(7) + 2(15) = 44$	66	no
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12.5	$(12.5) + 8 = 20.5$	$2(12.5) + 2(20.5) = 66$	66	yes
w	(w) + 8	$2(w) + 2(w+8) =$	66	YES!

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) Notice that our analytic equation gives the same answer as the table. To wrap this problem up, we will look at a geometric version that verifies our need to combine like terms.

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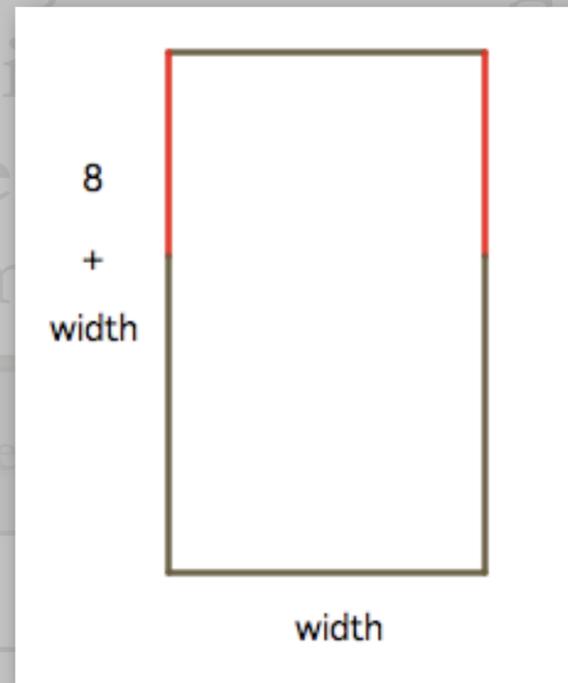
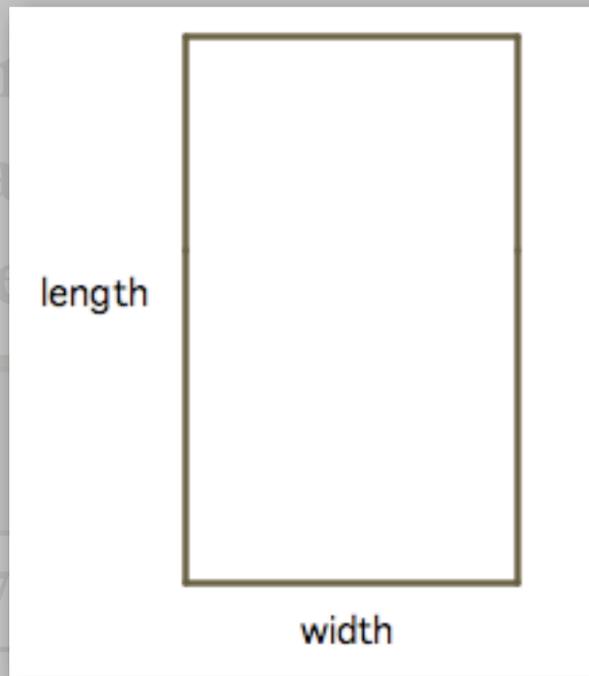
$$2w + 2w + 16 = 66$$

$$4w + 16 = 66$$

$$4w = 50$$

$$\frac{4w}{4} = \frac{50}{4}$$

$$12w = 12.5 \rightarrow l = 20.5$$



12.5	$(12.5) + 8 = 20.5$	$2(12.5) + 2(20.5) = 66$	66	yes
w	$(w) + 8$	$2(w) + 2(w+8) =$	66	YES!

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) Graphic solution – dimensions defined with variable (width)

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$$4w + 16 = 66$$

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$$\frac{4w}{4} = \frac{50}{4}$$

$$12w = 12.5 \rightarrow l = 20.5$$

12.5

$$(12.5) + 8 = 20.5$$

$$2(12.5) + 2(20.5) = 66$$

66

yes

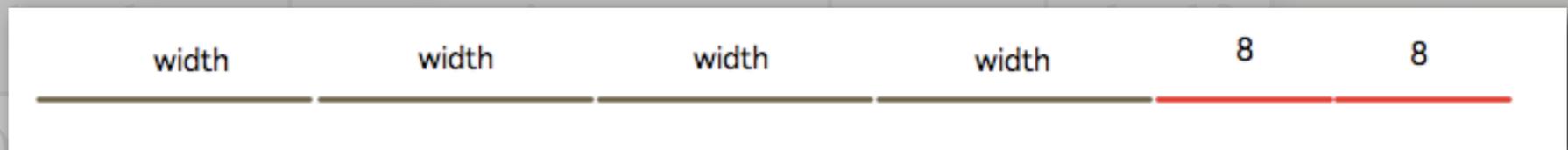
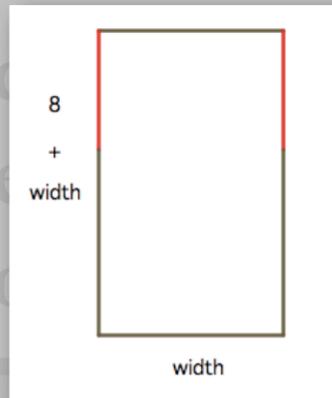
w

$$(w) + 8$$

$$2(w) + 2(w+8) =$$

66

YES!



				8	8
width	width	width	width	8	8
$4w$	50	$2(10) + 2(18) = 56$	66	no	
$12w = 12.5$	$\rightarrow l = 20.5$	$2(12) + 2(20) = 64$	66	no	
12.5	$(12.5) + 8 = 20.5$	$2(12.5) + 2(20.5) = 66$	66	yes	
w	$(w) + 8$	$2(w) + 2(w+8) =$	66	YES!	

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) Graphic solution – lying out the perimeter we see 4w's and 2 8's.

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$$2w + 2 \cdot (w + 8) = 66$$

$$2w + 2 \cdot w + 2 \cdot 8 = 66$$

$$2w + 2w + 16 = 66$$

$$4w + 16 = 66$$

$$4w - 16 = 66 - 16$$

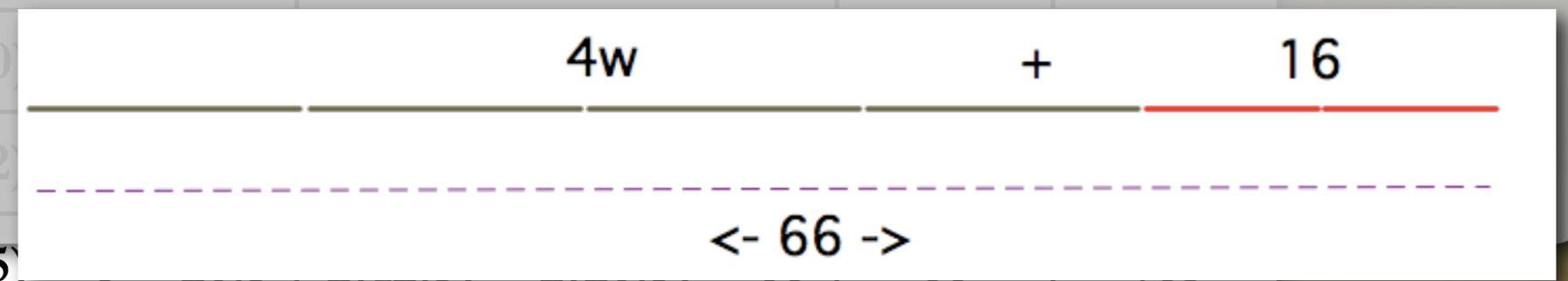
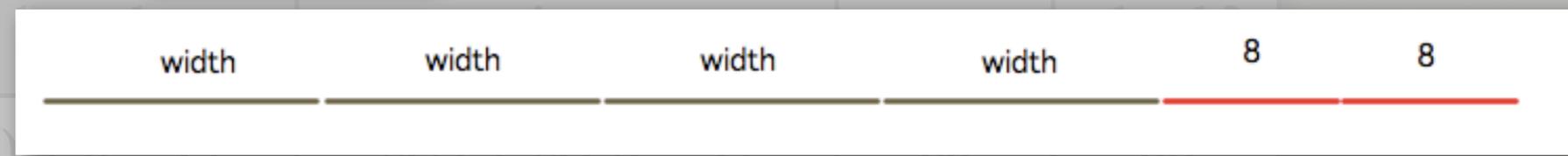
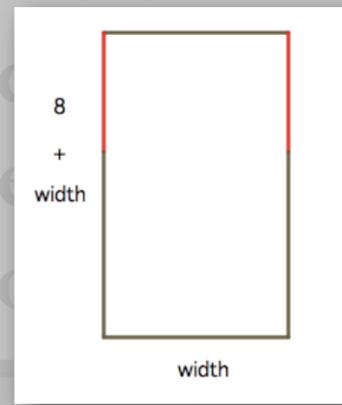
$$4w = 50$$

$$\frac{4w}{4} = \frac{50}{4}$$

$$w = 12.5$$

$$12.5$$

$$12.5$$



12.5	(12.5)				
w	(w) + 8	2(w) + 2(w+8)	=	66	YES!

The dimensions of the room are 12.5 by 20.5 feet.

(Large group discussion) The value of the perimeter is 4w's and 16, which has to equal the known 66 feet.

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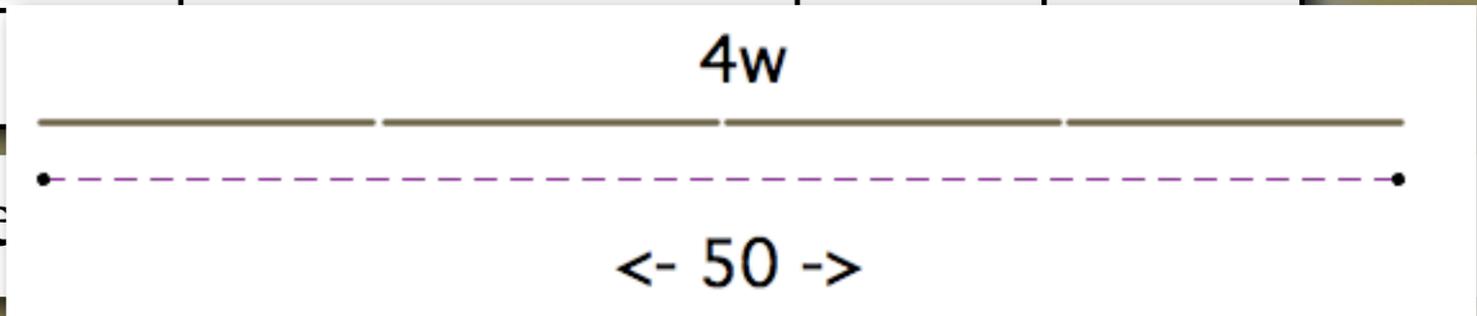
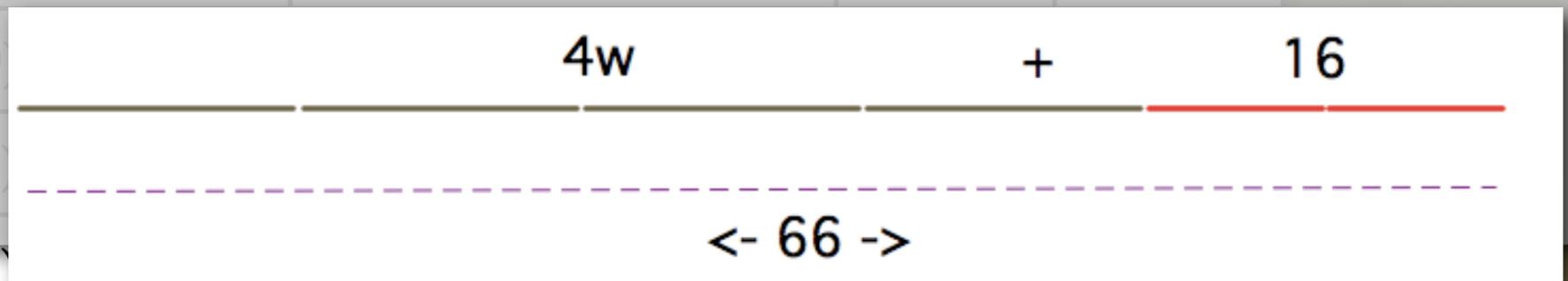
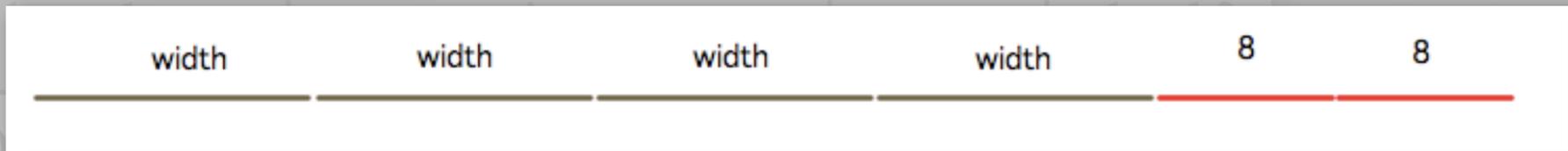
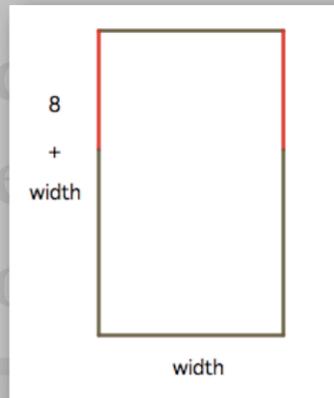
$$\frac{4w}{4} = \frac{50}{4}$$

$$12w = 12.5$$

$$12.5 \quad (12.5)$$

w

(w) +



The dimensions of the

(Large group discussion) If we remove the +16, we see that our 4w's must equal 50.

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$$2w + 2 \cdot w + 2 \cdot 8 = 66$$

$$2w + 2w + 16 = 66$$

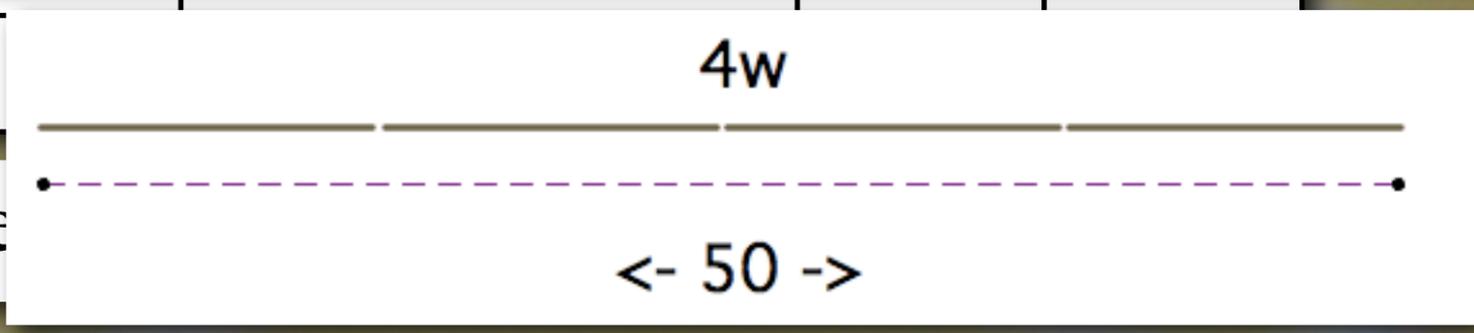
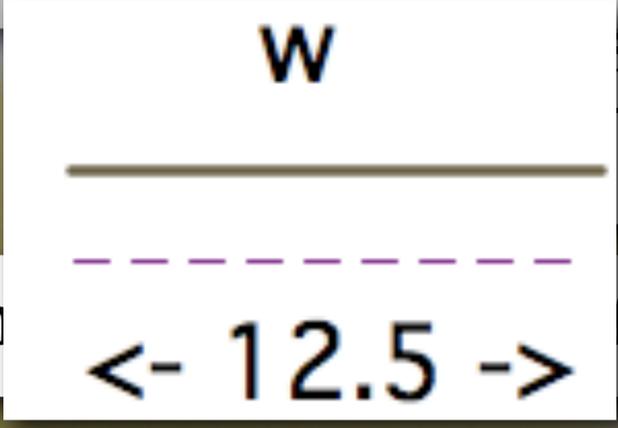
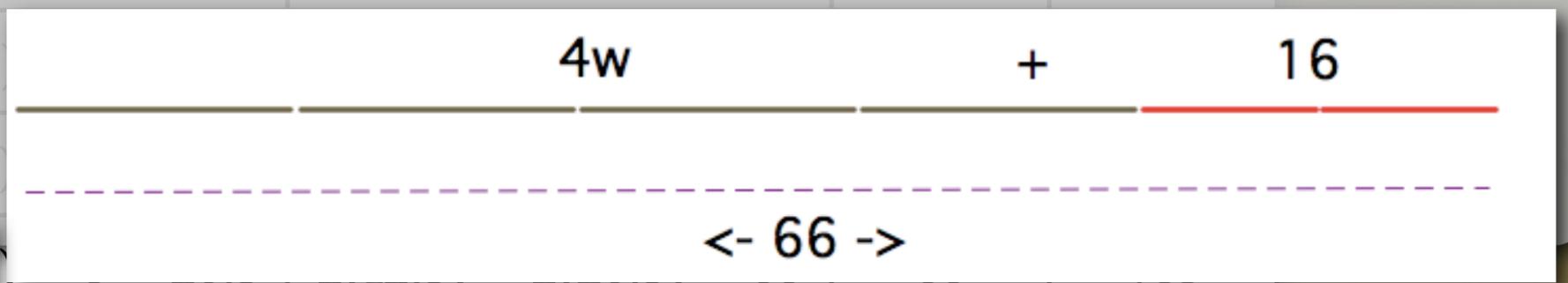
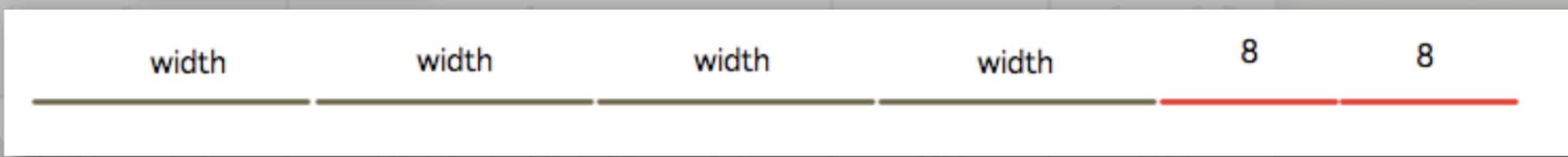
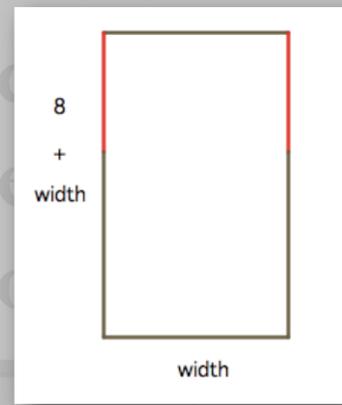
$$4w + 16 = 66$$

$$\begin{array}{r} -16 \\ -16 \end{array}$$

$$4w = 50$$

$$\frac{4w}{4} = \frac{50}{4}$$

$$12w = 12.5$$



The width of the room is 12.5 feet.

(Large group discussion) If 4 w's equal 50, then 1 w must be 12.5 and we've got our solution again.

Can you ace the ACT?

The 6 consecutive integers below add up to 447.

$$x - 2$$

$$x - 1$$

$$x$$

$$x + 1$$

$$x + 2$$

$$x + 3$$

What is the value of x ?

F. 72

G. 73

H. 74

J. 75

K. 76

(Small group discussion) The problem above is from ACT practice material (2007 Preparing for the ACT www.act.org/aap/pdf/preparing.pdf). This particular problem requires skills that we have established in this course.

Can you ace the ACT?

The 6 consecutive integers below add up to 447.

$$\begin{aligned}x - 2 \\x - 1 \\x \\x + 1 \\x + 2 \\x + 3\end{aligned}$$

What is the value of x ?

F. 72

G. 73

H. 74

J. 75

K. 76

$$(x - 2) + (x - 1) + (x) + (x + 1) + (x + 2) + (x + 3) = 447$$

$$(x - 2) + (x - 1) + (x) + (x + 1) + (x + 2) + (x + 3) = 447$$

$$6x + 3 = 447$$

$$6x = 444$$

$$x = 74$$

(Small group discussion) Solution - notice the combining of like terms.

How many quarters and dimes?

I have a bag of quarters and dimes that I take to cash in at the bank. Their machine tells me that there were 813 coins and the value I get back is \$147.90.

How many of each coin was there?

(Small group discussion) Students may be able to guess at the answer, and that's how we are going to start (with a table), but soon after we will create an equation to speed things up.

How many quarters and dimes?

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How many of each coin was there?

# quarters	# dimes	total value	target	check?
0	813	$.25(0) + .10(813) = 81.30$	147.90	no
813	0	$.25(813) + .10(0) = 203.25$	147.90	no

(Large class discussion) Be sure to let students struggle with the problem before teacher begins to explain how to do the problem. Let students share their own solutions first- think of this solution as a quick summary after they already have completed the problem... a time of analysis to see if there is another (preferred) method than the one they chose.

I started with the extremes to get a feel for the problem. From this, I think that I'll have more quarters than dimes.

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813	0	$.25(813) + .10(0) = 203.25$	147.90	no
700	113	$.25(700) + .10(113) = 186.30$	147.90	no
500	313	$.25(500) + .10(313) = 156.30$	147.90	no...

(Large class discussion) Now I'm starting high with quarters and moving down. I can see that I'm moving towards an answer, but I'm going to move to an analytic solution to speed things up.

How many quarters and dimes?

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700	113	$.25(700) + .10(113) = 186.30$	147.90	no
500	313	$.25(500) + .10(313) = 156.30$	147.90	no...
x	813 - x	$.25(x) + .10(813 - x)$	147.90	YES! (once we solve it)

(Large class discussion) From the pattern of the table, it is clear how we must set-up our equation. Now to solve it...

How many quarters and dimes?

# quarters	# dimes	total value	target
0	813	$.25(0) + .10(813) = 81.30$	147.90
813	0	$.25(813) + .10(0) = 203.25$	147.90
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x	813 - x	$.25(x) + .10(813 - x)$	147.90

$$.25(x) + .10(813 - x) = 147.90$$

$$.25x + .10 \cdot 813 - .10 \cdot x = 147.90$$

$$.15x + 81.3 = 147.90$$

$$- 81.3 \quad - 81.3$$

$$.15x = 66.60$$

$$\frac{.15x}{.15} = \frac{66.60}{.15}$$

$$x = 444$$

(Large class discussion) To solve the equation, make sure that students can justify each step (as the next set of slides does).

How many quarters and dimes?

$$.25(x) + .10(813 - x) = 147.90$$

What is step 1?

# quarters	# dimes	total value	target
0	813	$.25(0) + .10(813) = 81.30$	147.90
813	0	$.25(813) + .10(0) = 203.25$	147.90
700	113	$.25(700) + .10(113) = 186.30$	147.90
500	313	$.25(500) + .10(313) = 156.30$	147.90
x	813 - x	$.25(x) + .10(813 - x)$	147.90

OPTIONAL set of slides – justification of each step of the equation. Use as much as your students need it.

How many quarters and dimes?

$$.25(x) + .10(813 - x) = 147.90$$

Step 1: distributive property

$$.25x + .10 \cdot 813 - .10 \cdot x = 147.90$$

What is step 2?

# quarters	# dimes	total value	target
0	813	$.25(0) + .10(813) = 81.30$	147.90
813	0	$.25(813) + .10(0) = 203.25$	147.90
700	113	$.25(700) + .10(113) = 186.30$	147.90
500	313	$.25(500) + .10(313) = 156.30$	147.90
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x	813 - x	$.25(x) + .10(813 - x)$	147.90

$$.25(x) + .10(813 - x) = 147.90$$

Step 1: distributive property

$$.25x + .10 \cdot 813 - .10 \cdot x = 147.90$$

Step 2: Combine like terms

$$.15x + 81.3 = 147.90$$

What is step 3?

OPTIONAL set of slides – justification of each step of the equation. Use as much as your students need it.

How many quarters and dimes?

# quarters	# dimes	total value	target
0	813	$.25(0) + .10(813) = 81.30$	147.90
813	0	$.25(813) + .10(0) = 203.25$	147.90
700	113	$.25(700) + .10(113) = 186.30$	147.90
500	313	$.25(500) + .10(313) = 156.30$	147.90
x	813 - x	$.25(x) + .10(813 - x)$	147.90

$$.25(x) + .10(813 - x) = 147.90$$

Step 1: distributive property

$$.25x + .10 \cdot 813 - .10 \cdot x = 147.90$$

Step 2: Combine like terms

$$\begin{aligned} .15x + 81.3 &= 147.90 \\ - 81.3 &\quad - 81.3 \end{aligned}$$

Step 3: Additive Property of Equality

$$.15x = 66.60$$

What is step 4?

OPTIONAL set of slides – justification of each step of the equation. Use as much as your students need it.

How many quarters and dimes?

# quarters	# dimes	total value	target
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813	0	$.25(813) + .10(0) = 203.25$	147.90
700	113	$.25(700) + .10(113) = 186.30$	147.90
500	313	$.25(500) + .10(313) = 156.30$	147.90
x	813 - x	$.25(x) + .10(813 - x)$	147.90

$$.25(x) + .10(813 - x) = 147.90$$

Step 1: distributive property

$$.25x + .10 \cdot 813 - .10 \cdot x = 147.90$$

Step 2: Combine like terms

$$.15x + 81.3 = 147.90$$

$$- 81.3 \qquad \qquad - 81.3$$

Step 3: Additive Property of Equality

$$.15x = 66.60$$

Step 4: Multiplicative Property of Equality

$$\frac{.15x}{.15} = \frac{66.60}{.15}$$

$$x = 444$$

OPTIONAL set of slides – justification of each step of the equation. Use as much as your students need it.

How many quarters and dimes?

# quarters	# dimes	total value	target
0	813	$.25(0) + .10(813) = 81.30$	147.90
813	0	$.25(813) + .10(0) = 203.25$	147.90
700	113	$.25(700) + .10(113) = 186.30$	147.90
500	313	$.25(500) + .10(313) = 156.30$	147.90
444	$813 - 444 = 369$	$.25(x) + .10(813 - x)$	147.90

$$.25(x) + .10(813 - x) = 147.90$$

$$.25x + .10 \cdot 813 - .10 \cdot x = 147.90$$

$$.15x + 81.3 = 147.90$$

$$- 81.3 \quad - 81.3$$

$$.15x = 66.60$$

$$\frac{.15x}{.15} = \frac{66.60}{.15}$$

$$x = 444$$

(Large class discussion) To solve the equation, make sure that students can justify each step (as the next set of slides does).

How many quarters and dimes?

I have a bag of quarters and dimes that I take to cash in at the bank.

Their machine tells me that there were 813 coins and the value I get back is \$147.90.

How many of each coin was there?

# quarters	# dimes	total value	target	check?
0	813	$.25(0) + .10(813) = 81.30$	147.90	no
813	0	$.25(813) + .10(0) = 203.25$	147.90	no
700	113	$.25(700) + .10(113) = 186.30$	147.90	no
500	313	$.25(500) + .10(313) = 156.30$	147.90	no...
444	$813 - 444 = 369$	$.25(444) + .10(369) = 147.90$	147.90	YES!

(Large class discussion) To solve the equation, make sure that students can justify each step (as the next set of slides does).

How much of each candy should Sandy buy?



jelly beans vs. gummy worms (you should probably bring some to class for this day...)
(Large group discussion – for a moment) Have students decide what information they need

How much of each candy should Sandy buy?

Sandy wants to buy her friend 10 lbs of candy and spend \$34.

Jelly beans cost \$4 per pound and gummy worms cost \$2.50 per pound.

How much of each candy, should Sandy buy?

(Small group discussion OR homework) Students now have enough information to solve in groups. Give work time, and then review with the slides afterwards.

How much of each candy should Sandy buy?

Sandy wants to buy her friend 10 lbs of candy and spend \$34.

Jelly beans cost \$4 per pound and gummy worms cost \$2.50 per pound.

lbs of beans	lbs of worms	total cost	target	check?
			\$34	
			\$34	
			\$34	
			\$34	
			\$34	

(Small group discussion OR homework) If students are still stuck, suggest this chart.

How much of each candy should Sandy buy?

Sandy wants to buy her friend 10 lbs of candy and spend \$34.

Jelly beans cost \$4 per pound and gummy worms cost \$2.50 per pound.

lbs of beans	lbs of worms	total cost	target	check?
0	10	$4(0) + 2.5(10) = 25$	\$34	no
10	0	$4(10) + 2.5(0) = 40$	\$34	no
			\$34	
			\$34	
			\$34	

(Small group discussion OR homework) Extremes. Since \$40 is closer to \$34, I'm going to check to see if there are more beans.

How much of each candy should Sandy buy?

Sandy wants to buy her friend 10 lbs of candy and spend \$34.

Jelly beans cost \$4 per pound and gummy worms cost \$2.50 per pound.

lbs of beans	lbs of worms	total cost	target	check?
0	10	$4(0) + 2.5(10) = 25$	\$34	no
10	0	$4(10) + 2.5(0) = 40$	\$34	no
8	2	$4(8) + 2.5(2) = 37$	\$34	no
			\$34	
			\$34	

(Small group discussion OR homework) I'm getting close.

How much of each candy should Sandy buy?

Sandy wants to buy her friend 10 lbs of candy and spend \$34.

Jelly beans cost \$4 per pound and gummy worms cost \$2.50 per pound.

lbs of beans	lbs of worms	total cost	target	check?
0	10	$4(0) + 2.5(10) = 25$	\$34	no
10	0	$4(10) + 2.5(0) = 40$	\$34	no
8	2	$4(8) + 2.5(2) = 37$	\$34	no
6	4	$4(6) + 2.5(4) = 34$	\$34	YES!
			\$34	

(Small group discussion OR homework) We've got an answer using a numeric solution. If we want an analytic version, its on the next slides.

How much of each candy should Sandy buy?

Sandy wants to buy her friend 10 lbs of candy and spend \$34.

Jelly beans cost \$4 per pound and gummy worms cost \$2.50 per pound.

lbs of beans	lbs of worms	total cost	target	check?
0	10	$4(0) + 2.5(10) = 25$	\$34	no
10	0	$4(10) + 2.5(0) = 40$	\$34	no
8	2	$4(8) + 2.5(2) = 37$	\$34	no
6	4	$4(6) + 2.5(4) = 34$	\$34	YES!
x	10 - x	$4(x) + 2.5(10-x) =$	\$34	it will...

(Small group discussion OR homework) Analytic solution set-up.

How much of each candy should Sandy buy?

$$\begin{aligned}
 4x + 2.5(10 - x) &= 34 \\
 4x + 25 - 2.5x &= 34 \\
 1.5x + 25 &= 34 \\
 \underline{-25} & \quad \underline{-25} \\
 1.5x &= 9 \\
 \underline{1.5x} & \quad \underline{9} \\
 1.5 &= 1.5
 \end{aligned}$$

lbs of beans	lbs of worms	x	total cost =	target	check?
0	10		$4(0) + 2.5(10) = 25$	\$34	no
10	0		$4(10) + 2.5(0) = 40$	\$34	no
8	2		$4(8) + 2.5(2) = 37$	\$34	no
6	4		$4(6) + 2.5(4) = 34$	\$34	YES!
x	$10 - x$		$4(x) + 2.5(10-x) =$	\$34	it will...

(Small group discussion OR homework) Analytic solution.

How much of each candy should Sandy buy?

$$\begin{aligned}
 4x + 2.5(10 - x) &= 34 \\
 4x + 25 - 2.5x &= 34 \\
 1.5x + 25 &= 34 \\
 \underline{-25} & \quad \underline{-25} \\
 1.5x &= 9 \\
 \underline{1.5x} & \quad \underline{\quad} \\
 1.5 &= 1.5
 \end{aligned}$$

lbs of beans	lbs of worms	x	total cost =	target	check?
0	10		$4(0) + 2.5(10) = 25$	\$34	no
10	0		$4(10) + 2.5(0) = 40$	\$34	no
8	2				
6	4				
x	$10 - x$				

Sandy should buy 6 lbs of jelly beans and 4 lbs of gummy worms.

(Small group discussion OR homework) complete.

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