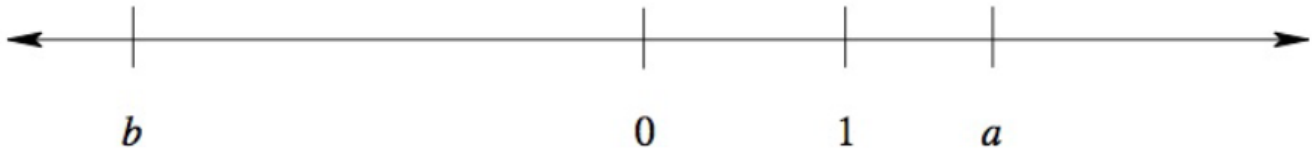


A number line is shown below. The numbers 0 and 1 are marked on the line, as are two other numbers a and b .



Which of the following numbers is negative? Choose all that apply. Explain your reasoning.

- a) $a - 1$ b) $a - 2$ c) $-b$ d) $a + b$ e) $a - b$

You may have learned some rules for doing arithmetic with positive and negative numbers. Many people find these rules hard to remember and don't understand where the rules come from.

The following mythical story provides a context for understanding how positive and negative numbers work. Many people find it easy to remember the story many years after they first heard it, and the memory of the story enables them to reconstruct the rules. The story also helps some people make sense of the rules.

The Story

In a far-off place, there was once a team of amazing chefs who cooked up the most marvelous food ever imagined.

They prepared their meals over a huge cauldron, and their work was very delicate and complex. During the cooking process, they frequently had to change the temperature of the cauldron in order to bring out the flavors and cook the food to perfection.

They adjusted the temperature of the cooking either by adding special hot cubes or cold cubes to the cauldron or by removing some of the hot or cold cubes that were already in the cauldron.

The cold cubes were similar to ice cubes except they didn't melt, and the hot cubes were similar to charcoal briquettes, except they didn't lose their heat.

If the number of cold cubes in the cauldron was the same as the number of hot cubes, the temperature of the cauldron was 0° on their temperature scale.

For each hot cube that was put into the cauldron, the temperature went up one degree; for each hot cube removed, the temperature went down one degree. Similarly, each cold cube put in lowered the temperature one degree and each cold cube removed raised it one degree.

The chefs used positive and negative numbers to keep track of the changes they were making to the temperature.

For example, suppose 4 hot cubes and 10 cold cubes were dumped into the cauldron. Then the temperature would be lowered by 6° altogether, since 4 of the 10 cold cubes would balance out the 4 hot cubes, leaving 6 cold cubes to lower the temperature 6° . The chefs would write $+4 + -10 = -6$ to represent these actions and their overall result.

Similarly, if they added 3 hot cubes and then removed 2 cold cubes, the combined result would be to raise the temperature 5° . In that case, they would write $+3 - -2 = +5$.

And if they wrote $-5 - +6 = -11$, it would mean that first 5 cold cubes were added and then 6 hot cubes were removed, and that the combined result was to lower the temperature 11° .

1. Each of the problems below describes an action by the chefs. Figure out how the temperature would change overall in each of these situations *and* write an equation to describe the action and the overall result.
 - a. Three cold cubes were added and 5 hot cubes were added.
 - b. Five hot cubes were added and 4 cold cubes were removed.
 - c. Six hot cubes were added, then 4 cold cubes were added, and finally 3 hot cubes were removed.
 - d. Four cold cubes were added, then 10 hot cubes were added, and finally 3 cold cubes were removed.

2. Describe the action involving hot or cold cubes that is represented by each of the following arithmetic expressions and state the final overall effect on the temperature.

- a. $4 - -3$
- b. $-6 + -4$
- c. $-4 - 6$
- d. $3 + -7$
- e. $-12 + 5$

3. For the following exercises,  = 1,  = -1; an expression for what the model represents.



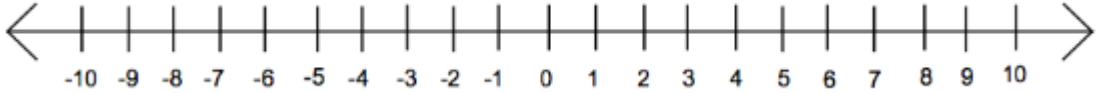
d. What is an additive inverse?

Number lines can also be used to model adding and subtracting integers. Use the number line below to model a football team that moves the football forward 9 yards on one play, then loses 7 yards on the next play. Then write an equation to represent the situation.

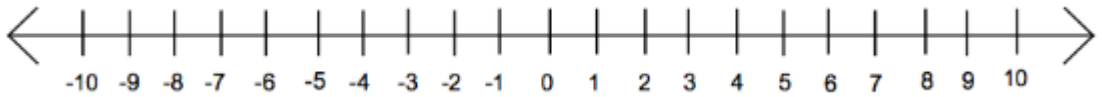


4. Use the number lines given show how to solve each problem.

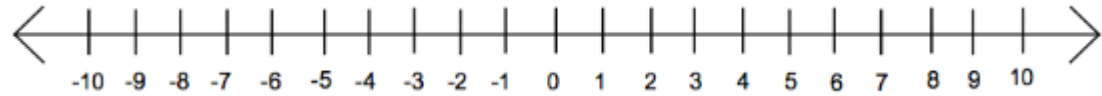
a. $4 + 3$



b. $-6 + -4$



c. $3 + -7$



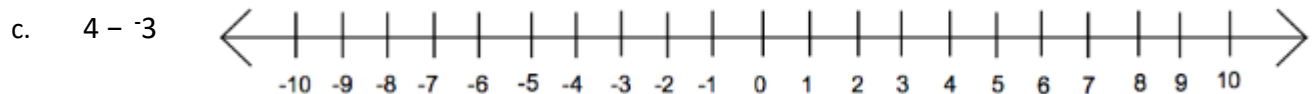
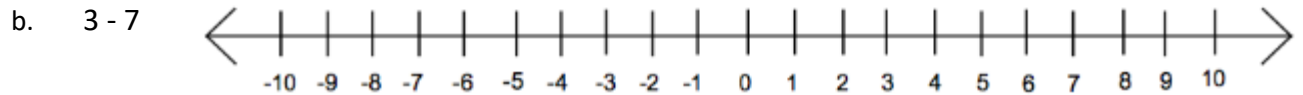
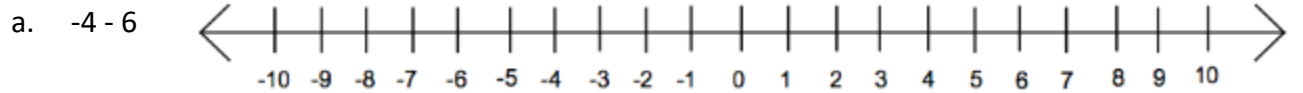
5. Expressions involving addition of integers can be rewritten as equivalent subtraction expressions. Fill in the table, then simplify each expression. The first one has been done for you.

Subtraction Expression	Addition Expression	Simplified
Example: $3 - 5$	$3 + (-5)$	-2
$-2 - 6$		
	$9 + (-14)$	
$-10 - (-7)$		
	$7 + 4$	
$12 - 8$		
	$-5 + -3$	
$6 - (-8)$		
	$-9 + 13$	

How will you decide if “-” means subtract or negative in a numeric expression?

How could we use a number line to show subtraction?

6. Use the number lines given show how to solve each problem.



7. Write an equation to represent each situation:

a. You ride your bike 12 miles and then get a flat tire! You turn around and walk the bike 4 miles before your mom is able to pick you up. How far are you from the house when your mom picks you up?

b. Zach's football team moves the football 35 yards forward on the first down. On the next down, they lose 12 yards. On the down after that they go forward 8 yards. How many yards total from the starting point did they move the football?

c. An osprey flies off the ground and reaches 35 feet above a river when he sees a trout. He then dives 37 feet down to get the trout. How many feet below the water does he end up?

8. Summarize how to add and subtract integers by writing some rules.