Lesson 2

Changing Temperatures

Goals

- Determine the final temperature given the starting temperature and the change in temperature, and explain (orally and using other representations) the solution method.
- Explain (orally) how to create a number line diagram that represents adding signed numbers.
- Write an addition equation to represent a situation involving a temperature increase or decrease.

Learning Target

I can use a number line to add positive and negative numbers.

Student Learning Goal

Let's add signed numbers.

Lesson Narrative

In this lesson, students represent addition of signed numbers on a number line. The convention used in this unit is that each addend is represented by an arrow and the sum is represented as a point on the number line. Positive addends are represented by arrows that point to the right, and negative addends are represented by arrows that point to the left. The first arrow starts at zero, and the next arrow starts where the first arrow ends. The sum is represented by a point on the number line where the arrow for the last addend ends.

This lesson uses the context of temperature to help students make sense of the addition equations. Students see that an increase in temperature can be represented as adding a positive value and a decrease in temperature can be represented as adding a negative value. As students use the context of temperature change to aid in reasoning about addition of signed numbers, they reason abstractly and quantitatively.

Access for Students with Diverse Abilities

- Representation (Activity 1)

Access for Multilingual Learners

- MLR7: Compare and Connect (Activity 2)
- MLR8: Discussion Supports (Activity 1)

Instructional Routines

- Which Three Go Together?

Required Preparation

Activity 2:
For the digital version of the activity, acquire devices that can run the applet.

If desired, prepare to display a map showing the locations of:

- Houston, TX
- Orlando, FL
- Salt Lake City, UT
- Minneapolis, MN
- Fairbanks, AK

Lesson Timeline

Warm-up	Activity 1	Activity 2	Lesson Synthesis	Assessment
5 min	15 min	10 min	10 min	10 min
				Cool-down

Instructional Routines

Which Three Go Together?

ilclass.com/r/10690736

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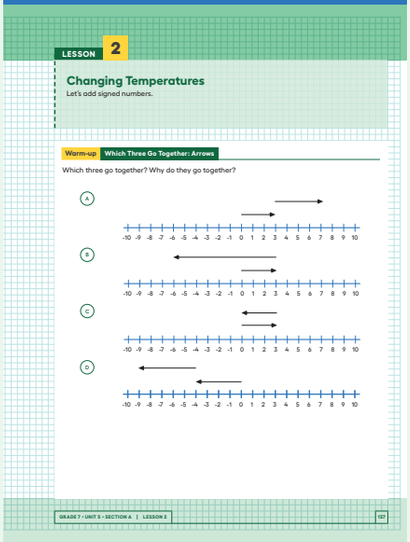
Student Workbook


LESSON 2

Changing Temperatures

Let's add signed numbers.

Warm-up Which Three Go Together: Arrows

Which three go together? Why do they go together?

A

B

C

D

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Warm-up

Which Three Go Together: Arrows

5 min

Activity Narrative

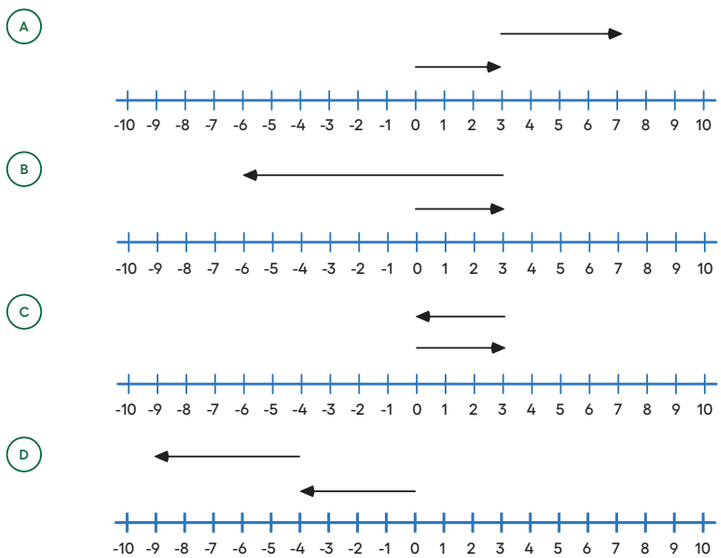
This *Warm-up* prompts students to compare four number line diagrams with arrows. It gives students a reason to use language precisely. It gives the teacher an opportunity to hear how students use terminology and talk about characteristics of the items in comparison to one another.

Launch

Arrange students in groups of 2–4. Display the images for all to see. Give students 1 minute of quiet think time, and ask them to indicate when they have noticed three images that go together and can explain why. Next, tell students to share their response with their group and then together find as many sets of three as they can.

Student Task Statement

Which three go together? Why do they go together?



Sample responses:

A, B, and C go together because:

- At least one arrow in each pair is pointing to the right.
- Each pair has an arrow pointing from 0 to 3.

A, B, and D go together because:

- Each pair has arrows of different lengths.

A, C, and D go together because:

- Each arrow is no longer than 5 units.
- Each pair of arrows stay on the same side of 0.

B, C, and D go together because:

- At least one arrow in each pair is pointing to the left.

Activity Synthesis

Invite each group to share one reason why a particular set of three go together. Record and display the responses for all to see. After each response, ask the class if they agree or disagree. Since there is no single correct answer to the question of which three go together, attend to students' explanations, and ensure the reasons given are correct.

During the discussion, prompt students to explain the meaning of any terminology they use, such as "positive," "negative," "addition," and "subtraction," and to clarify their reasoning as needed. Consider asking:

- *"How do you know ... ?"*
- *"What do you mean by ... ?"*
- *"Can you say that in another way?"*

Activity 1
Warmer and Colder

15 min

Activity Narrative

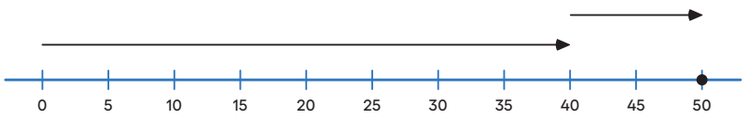
In this activity, students make sense of adding signed numbers using the context of temperature. They connect increases in temperature with positive numbers and decreases in temperature with negative numbers and then represent these increases and decreases on a number line. Students repeatedly add numbers to 40 and then to -20 to see that adding a positive number is the same as moving to the right on the number line and adding a negative number is the same as moving to the left on the number line.

Launch

Arrange students in groups of 2. Ask them,

- *"If the temperature starts at 40 degrees and increases 10 degrees, what will the final temperature be?"*

Show them this number line:



Explain how the diagram represents the situation, including the start temperature, the change, and the final temperature. Point out that in the table, this situation is represented by an equation where the initial temperature and change in temperature are added together to find the final temperature.

Next, ask students to think about the change in the second row of the table. Give students 1 minute of quiet work time to draw the diagram that shows a decrease of 5 degrees and to think about how they can represent this with an *addition* equation. Have them discuss with a partner for 1 minute. Ask a few students to share what they think the addition equation should be. Be sure students agree on the correct addition equation before moving on.

Instructional Routines

MLR8: Discussion Supports

ilclass.com/r/10695617

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Access for Multilingual Learners (Activity 1, Launch)

MLR8: Discussion Supports. Think aloud and use gestures to emphasize how to describe temperature change on a number line. For example, talk through the reasoning while representing and connecting the change on the number line and in the equation. This helps students to hear the language used to explain mathematical reasoning and to see how that mathematical language connects to a visual representation.

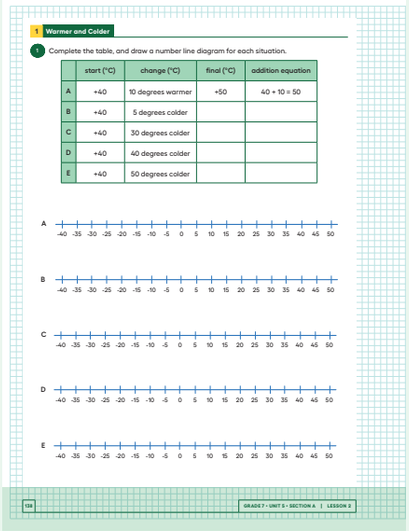
Advances: Listening, Representing

Access for Students with Diverse Abilities (Activity 1, Launch)

Representation: Develop Language and Symbols. Make connections between representations visible. For example, annotate the number line diagram to show how the starting temperature, the change, and the final temperature are represented. Encourage students to continue to annotate the number line diagrams for each situation in the task.

Supports accessibility for: Language, Conceptual Processing

Student Workbook


1 Warmer and Colder

1. Complete the table, and draw a number line diagram for each situation.

	start (°C)	change (°C)	final (°C)	addition equation
A	+40	10 degrees warmer	+50	40 + 10 = 50
B	+40	5 degrees colder		
C	+40	30 degrees colder		
D	+40	40 degrees colder		
E	+40	50 degrees colder		

A -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50

B -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50

C -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50

D -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50

E -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50

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Tell students they will be answering similar questions by doing the following steps:

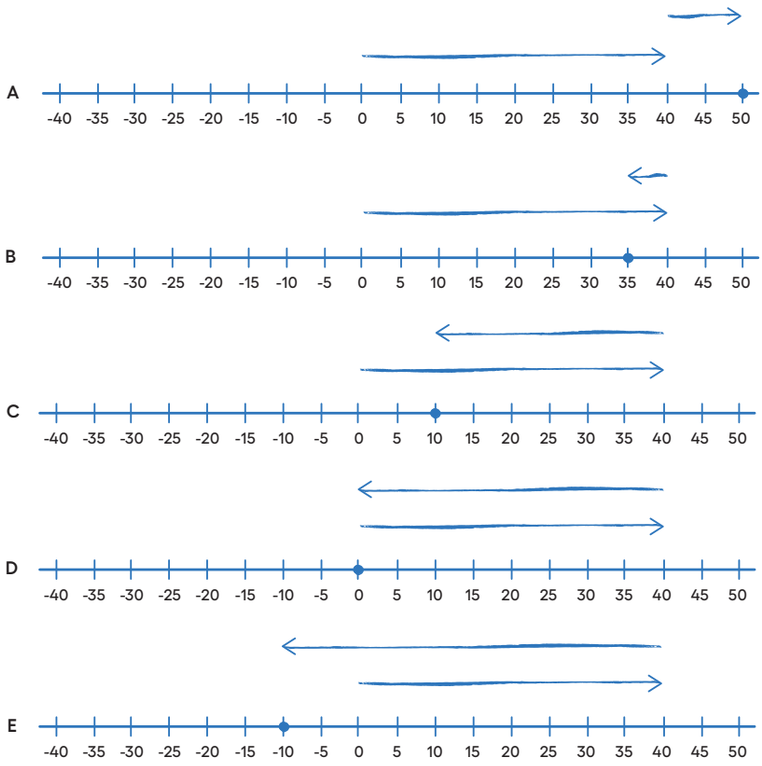
- Reasoning through the temperature change using whatever method makes sense
- Drawing a diagram to show the temperature change
- Writing an equation to represent the situation

Give students 4 minutes of quiet work time followed by time for partner discussion. Then follow with a whole-class discussion.

Student Task Statement

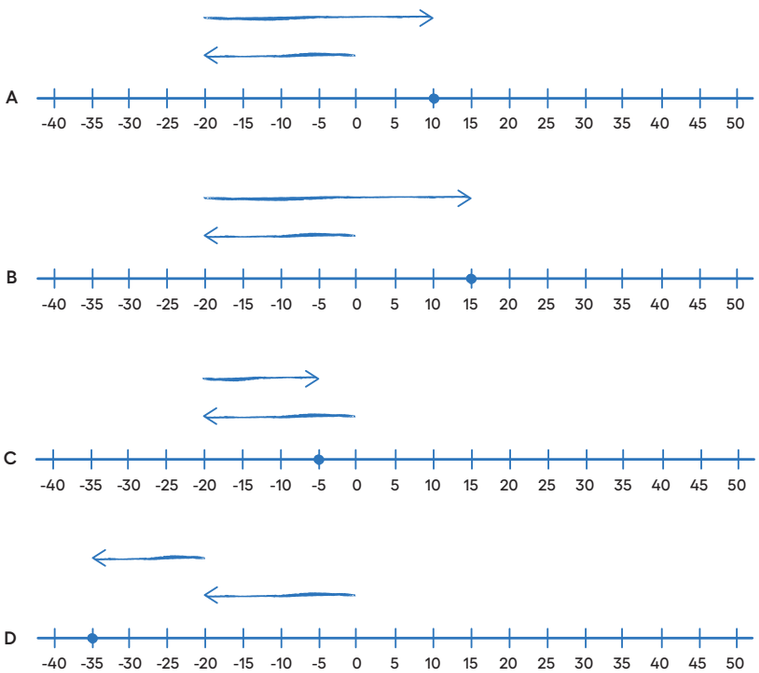
1. Complete the table, and draw a number line diagram for each situation.

	start (°C)	change (°C)	final (°C)	addition equation
A	+40	10 degrees warmer	+50	40 + 10 = 50
B	+40	5 degrees colder	+35	40 + -5 = 35
C	+40	30 degrees colder	+10	40 + -30 = 10
D	+40	40 degrees colder	0	40 + -40 = 0
E	+40	50 degrees colder	-10	40 + -50 = -10

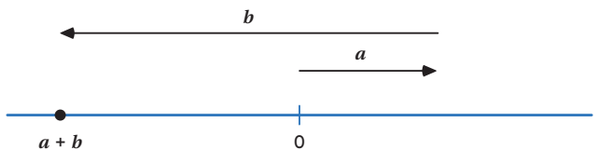


2. Complete the table, and draw a number line diagram for each situation.

	start (°C)	change (°C)	final (°C)	addition equation
A	-20	30 degrees warmer	+10	-20 + 30 = 10
B	-20	35 degrees warmer	+15	-20 + 35 = 15
C	-20	15 degrees warmer	-5	-20 + 15 = -5
D	-20	15 degrees colder	-35	-20 + -15 = -35



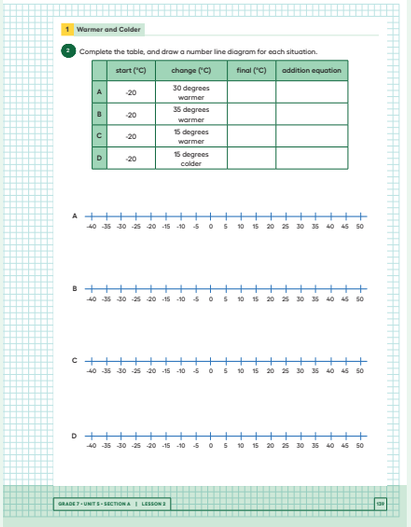
Are You Ready for More?



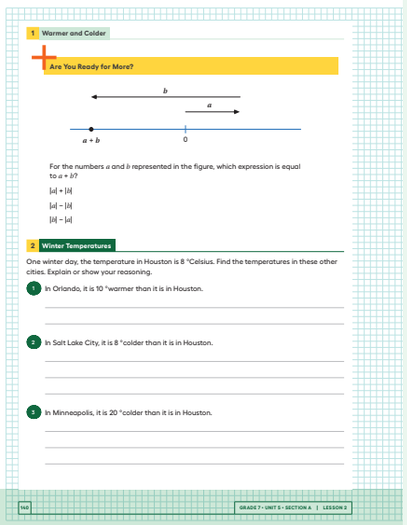
For the numbers a and b represented in the figure, which expression is equal to $a + b$?

- $|a| + |b|$
- $|a| - |b|$
- $|b| - |a|$

Student Workbook



Student Workbook



Instructional Routines

MLR7: Compare and Connect

ilclass.com/r/10695592

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Activity Synthesis

The purpose of this discussion is to review how adding positive and negative numbers can be represented on a horizontal number line. Here are some questions for discussion:

- *"How can we represent an increase in temperature on a number line?"*
  an arrow pointing to the right
- *"How can we represent a decrease in temperature on a number line?"*
  an arrow pointing to the left
- *"How are positive numbers represented on a number line?"*
  arrows pointing to the right
- *"How are negative numbers represented on a number line?"*
  arrows pointing to the left
- *"How can we represent a sum of two numbers?"*
  Draw the arrows so the tail of the second is located at the tip of the first.
- *"How can we determine the sum from the diagram?"*
  The sum is the number at the tip of the second arrow.
- *"What happens when we add a positive number to another number?"*
  The sum is located to the right of the first number on the number line.
- *"What happens when we add a negative number to another number?"*
  The sum is located to the left of the first number on the number line.

Activity 2

Winter Temperatures

10 min

Activity Narrative

There is a digital version of this activity.

In this activity, students reason about the temperature differences in different cities and connect them using an addition equation. Students may think of temperatures that are colder in terms of subtraction, which is one correct way to represent the situation. The focus in this activity is how to think about a situation with colder temperatures in terms of addition. Students will have an opportunity to connect addition and subtraction in a future lesson.

In the digital version of the activity, students use an applet to represent the change in temperature on a thermometer. The applet allows students to set the starting temperature and the temperature change and to see an equation that represents the situation. The digital version may be useful for students who would benefit from a visual representation of increasing and decreasing temperatures. The digital version may also be useful as a tool for students to check their work.

Launch

Before students start working, it may be helpful to display a map of the United States and point out the locations of the cities in the problem. Explain that in the northern hemisphere, it tends to be colder the farther north a location is.

Give students 5 minutes of quiet work time, and follow with a whole-class discussion.

Student Task Statement

One winter day, the temperature in Houston is 8° Celsius. Find the temperatures in these other cities. Explain or show your reasoning.

1. In Orlando, it is 10° warmer than it is in Houston.

18 °C

Sample reasoning: $8 + 10 = 18$

2. In Salt Lake City, it is 8° colder than it is in Houston.

0 °C

Sample reasoning: $8 + (-8) = 0$

3. In Minneapolis, it is 20° colder than it is in Houston.

-12 °C

Sample reasoning: $8 + (-20) = -12$

4. In Fairbanks, it is 10° colder than it is in *Minneapolis*.

-22 °C

Sample reasoning: $-12 + (-10) = -22$

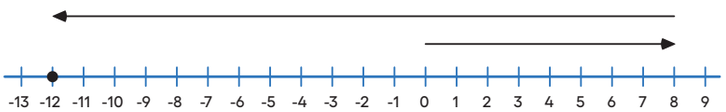
5. Write an addition equation that represents the relationship between the temperature in Houston and the temperature in Fairbanks.

$8 + (-20) + (-10) = -22$ (or equivalent)

Activity Synthesis

The goal of this discussion is for students to think about how to represent a colder temperature in terms of addition. Begin by inviting students to share their response and reasoning for finding the temperature in Minneapolis. If students correctly describe the situation in terms of subtraction with an equation such as 8 – 20 = -12, acknowledge that perspective, then ask them if they can also think of it in terms of addition.

If no students used a number line, display this diagram for Minneapolis for all to see, and consider discussing the following questions:



- *"How is the temperature of 8 degrees in Houston shown in the diagram?"*

  With an arrow pointing to the right with a magnitude of 8 and starting at 0.

- *"How is the change in temperature of 20 degrees colder in Minneapolis shown in the diagram?"*

  With an arrow pointing to the left with a magnitude of 20 and starting at the tip of the first arrow.

Access for Multilingual Learners (Activity 2, Launch)

MLR7: Compare and Connect. Lead a discussion comparing, contrasting, and connecting the different equations students wrote to describe the relationship between the temperature in Houston and the temperature in Fairbanks. Ask,

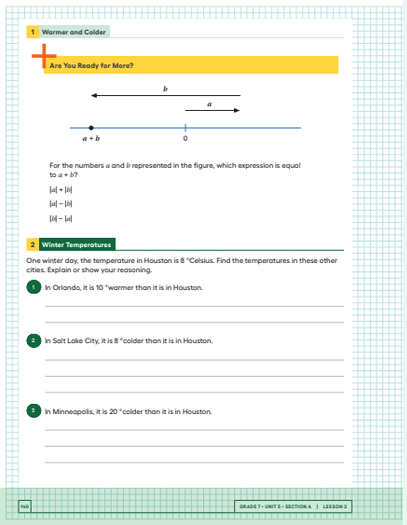
"How are the equations the same?"
"How are they different?"
"How does the difference in temperatures show up in each equation?"

Advances: Representing, Conversing

Building on Student Thinking

If students struggle to find the temperature in Minneapolis, because they think that 8 – 20 doesn't have an answer, suggest they represent the decrease in temperature as 8 + (-20) and use a number line to reason about the resulting temperature.

Student Workbook


1 Warmer and Colder

Are You Ready for More?

For the numbers a and b represented in the figure, which expression is equal to $a + b$?

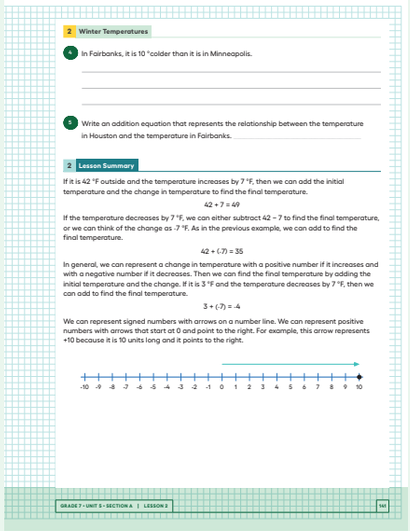
$|a| + |b|$
$|a| - |b|$
$|b| - |a|$

2 Winter Temperatures

One winter day, the temperature in Houston is 8 °Celsius. Find the temperatures in these other cities. Explain or show your reasoning.

1. In Orlando, it is 10 °warmer than it is in Houston.
2. In Salt Lake City, it is 8 °colder than it is in Houston.
3. In Minneapolis, it is 20 °colder than it is in Houston.

Student Workbook



2 Winter Temperatures

4. In Fairbanks, it is 10 °colder than it is in Minneapolis.

5. Write an addition equation that represents the relationship between the temperature in Houston and the temperature in Fairbanks.

2 Lesson Summary

If it is 42 °F outside and the temperature increases by 7 °F, then we can add the initial temperature and the change in temperature to find the final temperature.

42 + 7 = 49

If the temperature decreases by 7 °F, we can either subtract 42 – 7 to find the final temperature, or we can think of the change as -7 °F. As in the previous example, we can add to find the final temperature.

42 + (-7) = 35

In general, we can represent a change in temperature with a positive number if it increases and with a negative number if it decreases. Then we can find the final temperature by adding the initial temperature and the change. If it is 3 °F and the temperature decreases by 7 °F, then we can add to find the final temperature.

3 + (-7) = -4

We can represent signed numbers with arrows on a number line. We can represent positive numbers with arrows that start at 0 and point to the right. For example, this arrow represents +10 because it is 10 units long and it points to the right.

-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

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- *"How does this diagram show addition?"*

  When the tail of the second arrow is located at the tip of the first arrow, the diagram represents the sum of the two numbers.

- *"How can we represent this situation with an addition equation?"*

  $8 + (-20) = -12$.

Lesson Synthesis

Share with students,

- *"Today we represented changes in temperature with number line diagrams and addition expressions."*

To helps students connect these different representations, consider asking:

- *"How can we represent an increase in temperature on a number line?"*

  with an arrow pointing to the right

- *"How can we represent an increase in temperature with an addition expression?"*

  by adding a positive number

- *"How can we represent a decrease in temperature on a number line?"*

  with an arrow pointing to the left

- *"How can we represent a decrease in temperature with an addition expression?"*

  by adding a negative number

Lesson Summary

If it is 42 °F outside and the temperature increases by 7 °F, then we can add the initial temperature and the change in temperature to find the final temperature.

$$42 + 7 = 49$$

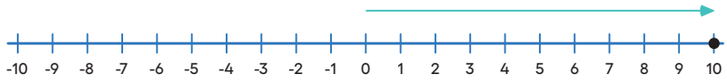
If the temperature decreases by 7°F, we can either subtract 42 – 7 to find the final temperature, or we can think of the change as -7 °F. As in the previous example, we can add to find the final temperature.

$$42 + (-7) = 35$$

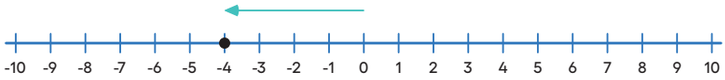
In general, we can represent a change in temperature with a positive number if it increases and with a negative number if it decreases. Then we can find the final temperature by adding the initial temperature and the change. If it is 3 °F and the temperature decreases by 7 °F, then we can add to find the final temperature.

$$3 + (-7) = -4$$

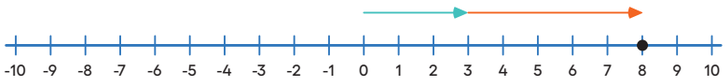
We can represent signed numbers with arrows on a number line. We can represent positive numbers with arrows that start at 0 and point to the right. For example, this arrow represents +10 because it is 10 units long and it points to the right.



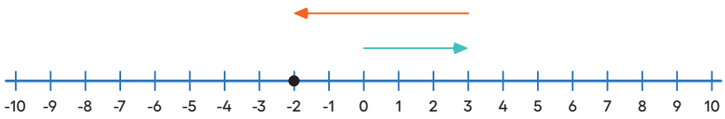
We can represent negative numbers with arrows that start at 0 and point to the left. For example, this arrow represents -4 because it is 4 units long and it points to the left.



To represent addition, we put the arrows "tip to tail." So this diagram represents 3 + 5:



And this diagram represents 3 + (-5):



Cool-down

Stories about Temperature

10 min

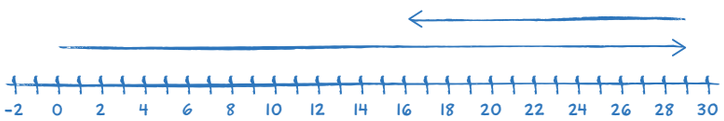
Student Task Statement

1. Write a story about temperatures that the following expression could represent: 27 + (-11)

   Sample response: It was 27 degrees at lunch time, and by the evening the temperature had dropped 11 degrees.

2. Draw a number line diagram and write an expression to represent this situation: "On Tuesday at lunchtime, it was 29 °C. By sunset, the temperature had dropped to 16 °C."

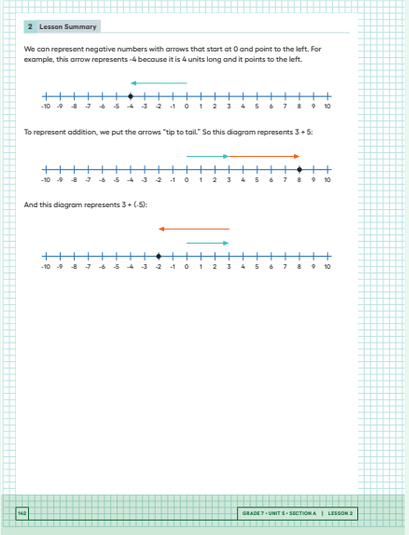
   Sample response: 29 + (-13)



Responding To Student Thinking

More Chances
Students will have more opportunities to understand the mathematical ideas addressed here. There is no need to slow down or add additional work to the next lessons.

Student Workbook


2 Lesson Summary

We can represent negative numbers with arrows that start at 0 and point to the left. For example, this arrow represents -4 because it is 4 units long and it points to the left.

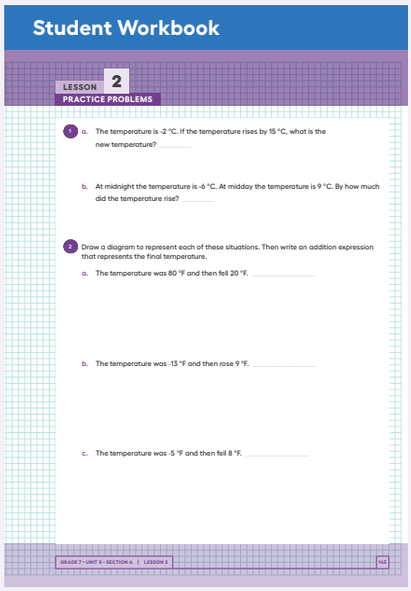
To represent addition, we put the arrows "tip to tail." So this diagram represents 3 + 5:

And this diagram represents 3 + (-5):

Lesson 2

Practice Problems

5 Problems


Student Workbook

LESSON 2
PRACTICE PROBLEMS

1 a. The temperature is -2 °C. If the temperature rises by 15 °C, what is the new temperature? _____

b. At midnight the temperature is -6 °C. At midday the temperature is 9 °C. By how much did the temperature rise? _____

2 Draw a diagram to represent each of these situations. Then write an addition expression that represents the final temperature.

a. The temperature was 80 °F and then fell 20 °F. _____

b. The temperature was -13 °F and then rose 9 °F. _____

c. The temperature was -5 °F and then fell 8 °F. _____

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Problem 1

a. The temperature is -2 °C. If the temperature rises by 15 °C, what is the new temperature?

13 °C

b. At midnight the temperature is -6 °C. At midday the temperature is 9 °C. By how much did the temperature rise?

15 °C

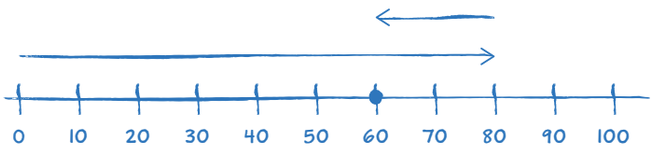
Problem 2

Draw a diagram to represent each of these situations. Then write an addition expression that represents the final temperature.

a. The temperature was 80 °F and then fell 20 °F.

80 + (-20)

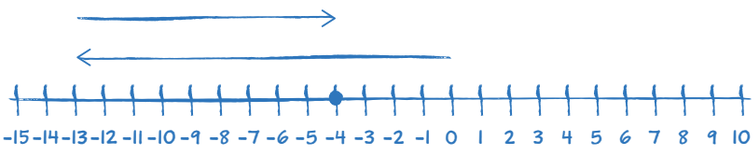
Sample response:



b. The temperature was -13 °F and then rose 9 °F.

-13 + 9

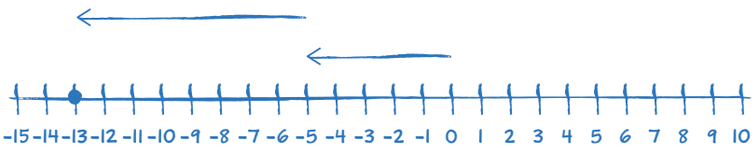
Sample response:



c. The temperature was -5 °F and then fell 8 °F.

-5 + (-8)

Sample response:



Problem 3

from Unit 5, Lesson 1

Complete each statement with a number that makes the statement true.

Sample response:

a. 5 °C < 7 °C

b. -8 °C < -3 °C

c. -0.8 °C < -0.7 °C < -0.1 °C

d. 4 °C > -2 °C

Problem 4

from Unit 2, Lesson 7

Decide whether each table could represent a proportional relationship. If the relationship could be proportional, what would be the constant of proportionality?

a. The number of wheels on a group of buses.

number of buses	number of wheels	wheels per bus
5	30	
8	48	
10	60	
15	90	

It could be proportional. The constant of proportionality would be 6 wheels per bus.

b. The number of wheels on a train.

number of train cars	number of wheels	wheels per train car
20	184	
30	264	
40	344	
50	424	

It could not be proportional. Every train car does not necessarily have the same number of wheels.

Problem 5

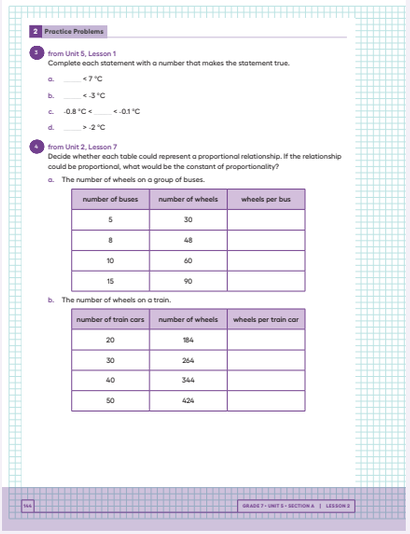
from Unit 4, Lesson 7

Noah was asked to make 32 tissue paper flowers as decorations for a party. He made 125% of that number. 90% of the paper flowers he made were used for the party. How many of Noah's flowers were not used?

4 flowers

He made 40 paper flowers, because $(1.25) \cdot 32 = 40$. Only 36 were used, because $(0.9) \cdot 40 = 36$. Therefore 4 were left because $40 - 36 = 4$.

Student Workbook


2 Practice Problems

3 from Unit 5, Lesson 1
Complete each statement with a number that makes the statement true.
a. ____ < 7 °C
b. ____ < -3 °C
c. -0.8 °C < ____ < -0.1 °C
d. ____ > -2 °C

4 from Unit 2, Lesson 7
Decide whether each table could represent a proportional relationship. If the relationship could be proportional, what would be the constant of proportionality?
a. The number of wheels on a group of buses.

number of buses	number of wheels	wheels per bus
5	30	
8	48	
10	60	
15	90	

b. The number of wheels on a train.

number of train cars	number of wheels	wheels per train car
20	184	
30	264	
40	344	
50	424	

Student Workbook


2 Practice Problems

5 from Unit 4, Lesson 7
Noah was asked to make 32 tissue paper flowers as decorations for a party. He made 125% of that number. 90% of the paper flowers he made were used for the party.
How many of Noah's flowers were not used? _____

Learning Targets
+ I can use a number line to add positive and negative numbers.