Lesson 9

Constant Speed

Goals

- Calculate the distance that an object travels in 1 unit of time and express it using a phrase like “meters per second” (orally and in writing).
- For an object moving at a constant speed, use a double number line diagram to represent equivalent ratios between the distance traveled and elapsed time.
- Justify (orally and in writing) which of two objects is moving faster, by identifying that it travels more distance in the same amount of time or that it travels the same distance in less time.

Learning Targets

- I can choose and create diagrams to help me reason about constant speed.
- If I know that an object is moving at a constant speed, and I know two of these things: the distance it travels, the amount of time it takes, and its speed, I can find the other thing.

Student Learning Goal

Let’s use ratios to work with how fast things move.

Lesson Narrative

This lesson introduces the context of **constant speed.** Through concrete experiences, students continue to explore equivalent ratios and ratios involving 1 unit. They measure the time it takes them to travel a predetermined distance moving slowly and then quickly—and use it to calculate and compare the speed they traveled in meters per second.

Here, double number lines are used to represent the association between distance and time, and to convey the idea of constant speed as a set of equivalent ratios. (For instance, 10 meters traveled in 20 seconds at a constant speed means that 0.5 meter is traveled in 1 second, and 5 meters are traveled in 10 seconds). Students come to understand that, like price, speed can be described using the terms *per* and *at this rate.*

Students reason quantitatively and abstractly as they think about constant speed as a measure that relates two quantities—distance and time. The idea of constant speed will be foundational for understanding constant rate, an even more abstract idea introduced later

Access for Students with Diverse Abilities

- Engagement (Activity 1)

Access for Multilingual Learners

- MLR7: Compare and Connect (Activity 1)

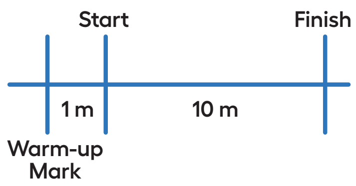
Required Materials

Materials to Gather

- Masking tape: Activity 1
- Meter sticks: Activity 1
- Stopwatches: Activity 1
- String: Activity 1

Required Preparation

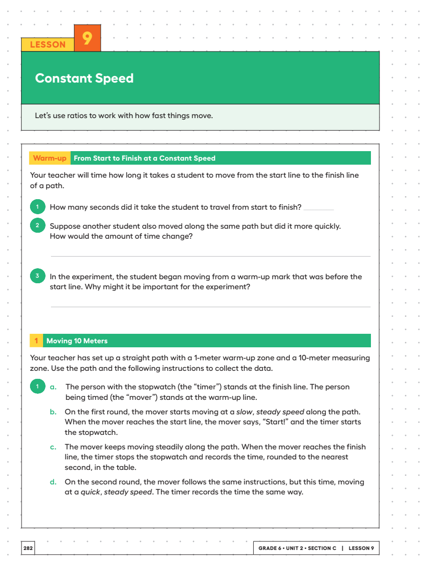
Warm-up:
Set up 4 paths as shown in the diagram, with a 1-meter warm-up zone and a 10-meter measuring zone. Mark the beginning of the warm-up zone, the start line, and the finish line.



Lesson Timeline

- 5 min — Warm-up
- 20 min — Activity 1
- 10 min — Activity 2
- 10 min — Lesson Synthesis
- Assessment: 5 min — Cool-down

Student Workbook


LESSON 9

Constant Speed

Let's use ratios to work with how fast things move.

Warm-up From Start to Finish at a Constant Speed

Your teacher will time how long it takes a student to move from the start line to the finish line of a path.

1 How many seconds did it take the student to travel from start to finish?

2 Suppose another student also moved along the same path but did it more quickly. How would the amount of time change?

3 In the experiment, the student began moving from a warm-up mark that was before the start line. Why might it be important for the experiment?

1 Moving 10 Meters

Your teacher has set up a straight path with a 1-meter warm-up zone and a 10-meter measuring zone. Use the path and the following instructions to collect the data.

1 a. The person with the stopwatch (the "timer") stands at the finish line. The person being timed (the "mover") stands at the warm-up line.

b. On the first round, the mover starts moving at a *slow, steady speed* along the path. When the mover reaches the start line, the mover says, "Start!" and the timer starts the stopwatch.

c. The mover keeps moving steadily along the path. When the mover reaches the finish line, the timer stops the stopwatch and records the time, rounded to the nearest second, in the table.

d. On the second round, the mover follows the same instructions, but this time, moving at a *quick, steady speed*. The timer records the time the same way.

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Warm-up

From Start to Finish at a Constant Speed

5 min

Activity Narrative

This *Warm-up* serves two purposes. The first purpose is to familiarize students with the protocol for the next activity, in which they will measure the time it takes someone to travel a distance at a **constant speed**. The second is to prompt students to begin thinking about the meaning of "constant speed." Students observe a demonstration of the time-measurement process, predict how the speed of movement affects the measured time, and consider why it might be important for the person being timed to begin moving before the timer starts.

Launch

Tell students that you will perform an experiment that involves timing how long it takes someone to move the distance from the start line to the finish line. Select a student to be your partner.

Ask the student to stand at the warm-up mark of one of the paths prepared before class. Explain that the student has two main tasks:

- To move at a slow and steady speed toward the finish line
- To say "Start!" when they reach the start line so that you know when to start the stopwatch

Explain that when they reach the finish line you will stop the stopwatch and record the time, rounding it to the nearest second.

Before starting, stress the importance of the student moving at a constant speed while being timed. To encourage them to move slowly, consider asking the student to move as if they are balancing something on their head or carrying a full cup of water, trying not to spill it.

Demonstrate the experiment. Tell the class when the stopwatch is started and when it is stopped. Record and display the time for all to see.

Give students 1–2 minutes to answer the questions.

Student Task Statement

Your teacher will time how long it takes a student to move from the start line to the finish line of a path.

1. How many seconds did it take the student to travel from start to finish?

   Answers vary.

2. Suppose another student also moved along the same path but did it more quickly. How would the amount of time change?

   It would take less time to travel the given distance if the student moved more quickly.

3. In the experiment, the student began moving from a warm-up mark that was before the start line. Why might it be important for the experiment?

   Sample responses:

   - It allows the student to get used to moving slowly before the timer starts.
   - It gives the student a chance to reach a constant speed before being timed.

Activity Synthesis

First, invite a few students to share their predictions about the time it would take a faster mover to go from start to finish. Make sure that students see that it would take a shorter amount of time to move the same distance at a faster speed.

Then, ask students to share why it might be important that the mover begins moving before the start line. Consider asking:

"Suppose the mover started moving from the start line instead of from the warm-up mark. What can you say about the speed of the mover just as they were leaving the start line? How would that speed compare to their speed later on the path?"

"What do you think 'constant speed' means?"

The key takeaway is that when an object moves at a **constant speed**, it doesn't move faster or slower at any time. The initial 1-meter-long stretch, the warm-up zone, is there so the mover can accelerate to a constant speed before the timing begins.

Tell students that in the next activity they will do the experiment in small groups. When it is their turn to be the mover, they will need to move at a constant speed.

Activity 1

Moving 10 Meters

20 min

Activity Narrative

This activity gives students first-hand experience in relating ratios of time and distance to speed. Students time one another as they move 10 meters at a constant speed—first slowly and then quickly—and then reason about the distance traveled in 1 second.

Double number lines play a key role in helping students see how time and distance relate to constant speed —allowing them to compare how quickly two objects are moving in two ways. They can look at how long it takes to move 10 meters (a shorter time needed to move 10 meters means faster movement), or they can look at how far one travels in 1 second (a longer distance in one second means faster movement).

Along the way, students see that the language of "per" and "at this rate," which was previously used to talk about unit price, is also relevant in the context of constant speed. They begin to use "meters per second" to express measurements of speed.

As students work, notice the different ways in which they use double number lines or other means to reason about distance traveled in one second.

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

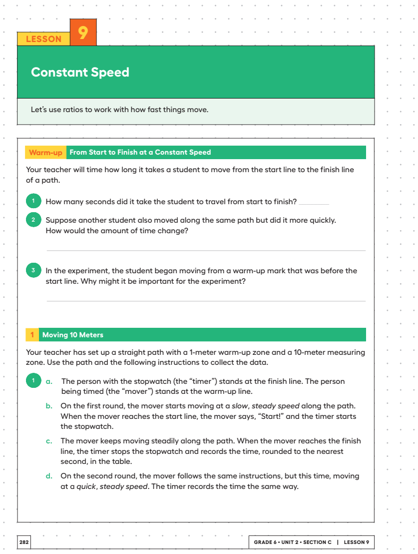
Engagement: Develop Effort and Persistence.

Provide guides and checklists that focus on increasing the length of on-task orientation in the face of distractions. For example, give students guidance on the time available for groups to gather data and for individuals to answer questions, along with a checklist showing the main components in each portion of the activity.
Supports accessibility for: Attention, Social-Emotional Functioning

Building on Student Thinking

Students may have difficulty estimating the distance traveled in 1 second. Encourage them to mark the double number line to help. For example, marking 5 meters halfway between 0 and 10 and determining the elapsed time as half the recorded total may cue them to use division.

Student Workbook


LESSON 9

Constant Speed

Let's use ratios to work with how fast things move.

Warm-up From Start to Finish at a Constant Speed

Your teacher will time how long it takes a student to move from the start line to the finish line of a path.

1. How many seconds did it take the student to travel from start to finish?

2. Suppose another student also moved along the same path but did it more quickly. How would the amount of time change?

3. In the experiment, the student began moving from a warm-up mark that was before the start line. Why might it be important for the experiment?

1 Moving 10 Meters

Your teacher has set up a straight path with a 1-meter warm-up zone and a 10-meter measuring zone. Use the path and the following instructions to collect the data.

1. a. The person with the stopwatch (the "timer") stands at the finish line. The person being timed (the "mover") stands at the warm-up line.

b. On the first round, the mover starts moving at a slow, steady speed along the path. When the mover reaches the start line, the mover says, "Start!" and the timer starts the stopwatch.

c. The mover keeps moving steadily along the path. When the mover reaches the finish line, the timer stops the stopwatch and records the time, rounded to the nearest second, in the table.

d. On the second round, the mover follows the same instructions, but this time, moving at a quick, steady speed. The timer records the time the same way.

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Launch

Arrange students into 4 groups. Provide a stopwatch and one path for each group to use. Tell students that they will gather some data on the time it takes to move 10 meters.

Explain that group members will take turns playing two roles: "the mover" and "the timer." The mover stands at the warm-up mark. The timer stands at the finish line with a stopwatch. Each mover will go twice—once slowly and once quickly. Each time:

Upon reaching the start line, the mover says, "Start!" and the timer starts the stopwatch.

When the mover reaches the finish line, the timer stops the stopwatch and records the time (rounded to the nearest second) in the table in the mover's workbook.

Consider establishing a way to support students in taking turns. One way is to ask group members to count off and play the two roles in order. Member 1 starts as the timer and Member 2 is the mover. Then, Member 2 becomes the timer and Member 3 the mover, and so on. This can help to ensure more efficient data collection and that every student has a turn in each role.

Select students who use different reasoning strategies to share during a later discussion.

Student Task Statement

Your teacher has set up a straight path with a 1-meter warm-up zone and a 10-meter measuring zone. Use the path and the following instructions to collect the data.

1. **a.** The person with the stopwatch (the "timer") stands at the finish line. The person being timed (the "mover") stands at the warm-up line.

   b. On the first round, the mover starts moving *at a slow, steady speed* along the path. When the mover reaches the start line, the mover says, "Start!" and the timer starts the stopwatch.

   c. The mover keeps moving steadily along the path. When the mover reaches the finish line, the timer stops the stopwatch and records the time, rounded to the nearest second, in the table.

   d. On the second round, the mover follows the same instructions, but this time, moving *at a quick, steady speed*. The timer records the time the same way.

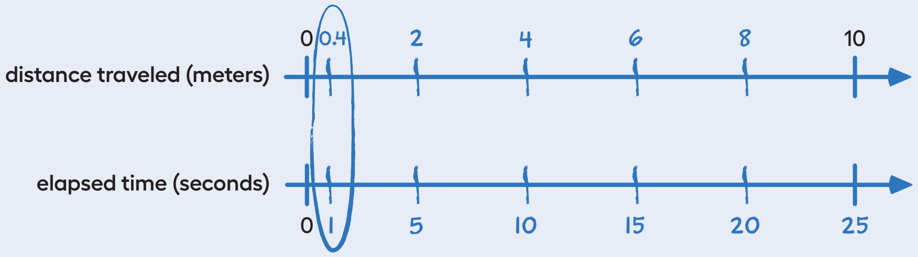
   e. Repeat these steps until each person in the group has gone twice: once at a slow, steady speed, and once at a quick, steady speed.

Sample responses:

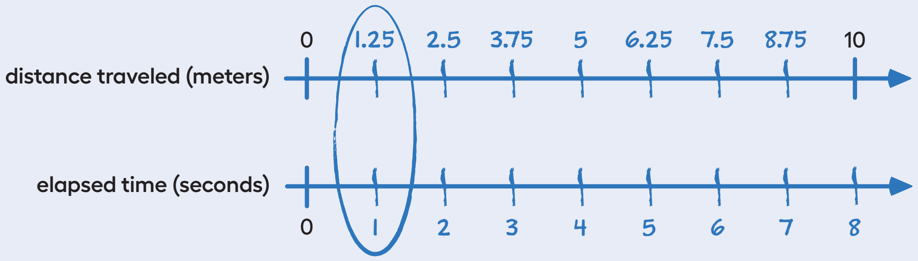
your slow moving time (seconds)	your fast moving time (seconds)
25	8

2. After you finish collecting the data, use the double number line diagrams to answer the questions. Use the times that your partner recorded when you were the person moving.

Moving slowly:



Moving quickly:



a. Estimate the distance in meters that you traveled in 1 second when moving slowly.

$\frac{2}{5}$ or 0.4 meter

b. Estimate the distance in meters that you traveled in 1 second when moving quickly.

$\frac{5}{4}$ or 1.25 meters

c. How is the diagram that represents you moving slowly different from the diagram that represents you moving quickly?

The diagram that represents moving quickly will have a higher number of meters at 1 second. It will have a lower number of seconds at 10 meters.

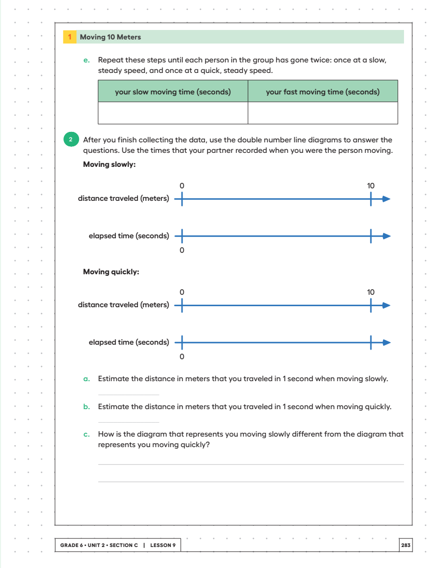
Activity Synthesis

Invite previously selected students to share how they reasoned about the distance traveled in 1 second. It may be helpful to discuss the appropriate amount of precision for their answers. Although dividing the distance by the elapsed time can result in a quotient with many decimal places, the nature of this activity leads to reporting an approximate answer.

During the discussion, demonstrate the use of the phrase *meters per second*. If it comes up naturally in students' explanations, emphasize it.

Discuss how we can use double number lines to distinguish faster movement from slower movement. If it hasn't already surfaced in discussion, help students see that we can compare the time it takes to travel the same distance (in this case, 10 meters) as well as the distance traveled in the same amount of time (for example, 1 second).

Student Workbook



Access for Multilingual Learners (Activity 1, Synthesis)

MLR7: Compare and Connect.

As students share different approaches for reasoning about distance traveled in 1 second, ask students to identify what is the same and what is different about the approaches. Help students connect approaches by asking:

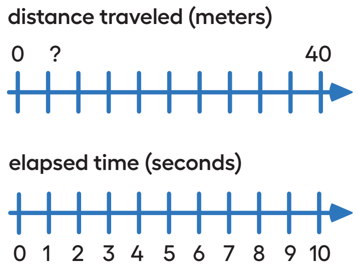
> *"Where do you see the measurement of speed '____ meters per second' in each approach?"*

This helps students relate the concept of rate and a visual representation of that rate.

Advances: Representing

Building on Student Thinking

Instead of dividing 40 by 10, some students may instead calculate 10 ÷ 40. Ask them to articulate what the resulting number means (0.25 seconds to travel 1 meter) and contrast that meaning with what the problem is asking (how many meters in one second). Another approach would be to encourage them to draw a double number line and think about how they can figure out what value for distance corresponds to 1 second on the line for elapsed time.



Student Workbook

Explain to students that when we represent time and distance on a double number line, we are saying that the object is traveling at a constant speed or a constant rate. This means that the ratios of meters traveled to seconds elapsed (or miles traveled to hours elapsed) are equivalent the entire time the object is traveling. The object does not move faster or slower at any time. The equal intervals on the double number line show this steady rate.

Activity 2

Moving for 10 Seconds

10 min

Activity Narrative

There is a digital version of this activity.

In this activity, students analyze a situation in which two people travel for the same amount of time, each at a constant speed, but go different distances. The use of double number lines is suggested, but not required.

Monitor students' work and notice the different ways in which students compare speeds. For the first question, students may use meters per second or compare the distance traveled in the same number of seconds. For the last question, they may draw a double number line for each of the scenarios being compared, or calculate each speed in meters per second.

In the digital version of the activity, students can choose to use an applet to create double number lines to represent given quantities, explore the problems, and solidify their thinking. The applet is the same as the one in an earlier lesson about grocery shopping.

Launch

Keep students with the same partners.

Give students quiet think time, and then time to share their responses with their partners.

Tell students that, in the last activity, everyone traveled the same distance but in different amounts of time. Now they will analyze a situation in which two people travel for the same amount of time but cover different distances.

Student Task Statement

Lin and Diego both ran for 10 seconds, each at their own constant speed. Lin ran 40 meters and Diego ran 55 meters.

1. Who was moving faster? Explain your reasoning.

   Diego ran faster, covering a greater distance in the same amount of time.

2. How far did each person move in 1 second? If you get stuck, consider drawing double number line diagrams to represent the situations.

   Lin ran 4 meters per second, and Diego ran 5.5 meters per second.

3. Use your data from the previous activity to find how far *you* could travel in 10 seconds at your quicker speed.

   Answers vary, but should show 10 times the distance traveled in 1 second.

4. Han ran 100 meters in 20 seconds at a constant speed. Is this speed faster, slower, or the same as Lin's? Diego's? Yours?

   Han ran 5 meters per second, which is faster than Lin's speed, but slower than Diego's.

Are You Ready for More?

Lin and Diego want to run a race in which they will both finish when the timer reads exactly 30 seconds. Who should get a head start, and how long should the head start be?

Lin needs a 45-meter head start. Lin will travel 120 meters in 30 seconds, and Diego will travel 165 meters in 30 seconds.

Activity Synthesis

Select students who reasoned differently to share their thinking. Some students will know that Diego ran faster, simply because he ran further, but this reasoning is not always correct. Han runs further, but is slower than Diego because he had more time. Be sure to attend to both distance and time when making the comparison. Help students draw connections between the different ways they represented and reasoned about the problem.

During the discussion, keep as much emphasis as possible on the concept of *meters per second*.

Lesson Synthesis

The work in this lesson parallels the work in the previous lesson. Knowing a speed in meters per second gives the same kind of information as knowing a unit price in dollars per item.

To help students see consistencies in the underlying mathematical structure of these contexts, consider asking:

- *"How is finding speed in meters per second like finding unit prices?"*

  They are both about finding the value of something for 1 unit of something else.

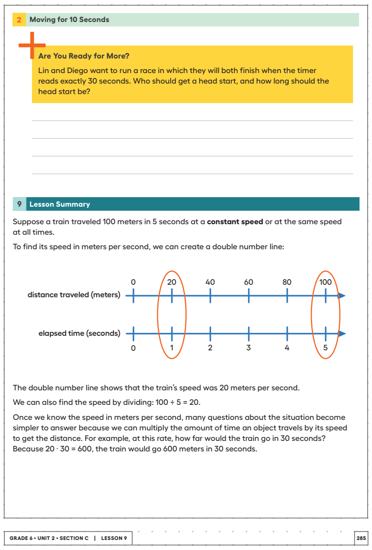
- *"Why might it be helpful to find speed in meters per second?"*

  It can help us find the distance traveled in any number of seconds. It can help us figure out how long it'd take to travel a particular distance.

- *"Compare the process of finding speed in meters per second and finding unit price. How are they alike or different?"*

  We can use division in both cases. To find unit price, we can divide a known price by the number of items or units. To find speed in meters per second, we can divide the distance in meters by the number of seconds to travel that distance. We can also use a double number line diagram to figure out both unit price and speed in meters per second.

Student Workbook



2 Moving for 10 Seconds

Are You Ready for More?

Lin and Diego want to run a race in which they will both finish when the timer reads exactly 30 seconds. Who should get a head start, and how long should the head start be?

9 Lesson Summary

Suppose a train traveled 100 meters in 5 seconds at a **constant speed** or at the same speed at all times.

To find its speed in meters per second, we can create a double number line:

The double number line shows that the train's speed was 20 meters per second.

We can also find the speed by dividing: $100 \div 5 = 20$.

Once we know the speed in meters per second, many questions about the situation become simpler to answer because we can multiply the amount of time an object travels by its speed to get the distance. For example, at this rate, how far would the train go in 30 seconds? Because $20 \cdot 30 = 600$, the train would go 600 meters in 30 seconds.

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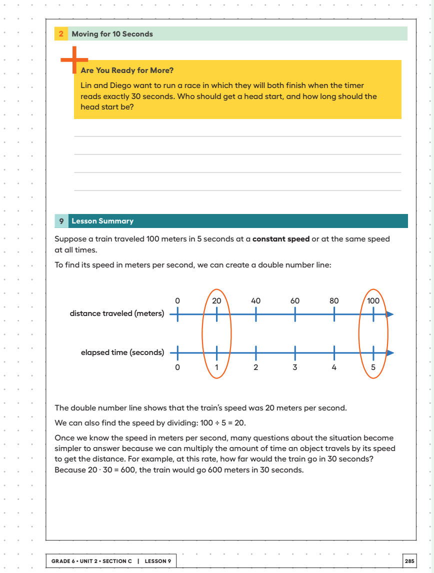
Student Workbook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Responding To Student Thinking

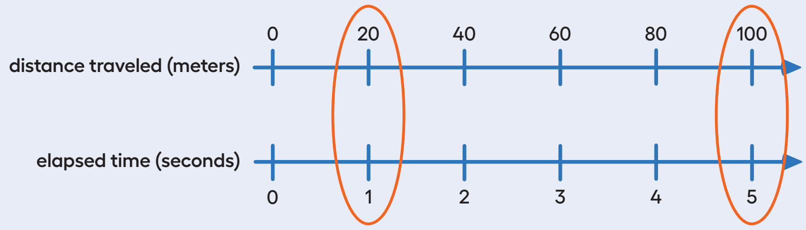
More Chances

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.

Lesson Summary

Suppose a train traveled 100 meters in 5 seconds at a **constant speed** or at the same speed at all times.

To find its speed in meters per second, we can create a double number line:



The double number line shows that the train's speed was 20 meters per second.

We can also find the speed by dividing: 100 ÷ 5 = 20.

Once we know the speed in meters per second, many questions about the situation become simpler to answer because we can multiply the amount of time an object travels by its speed to get the distance. For example, at this rate, how far would the train go in 30 seconds? Because 20 · 30 = 600, the train would go 600 meters in 30 seconds.

Cool-down

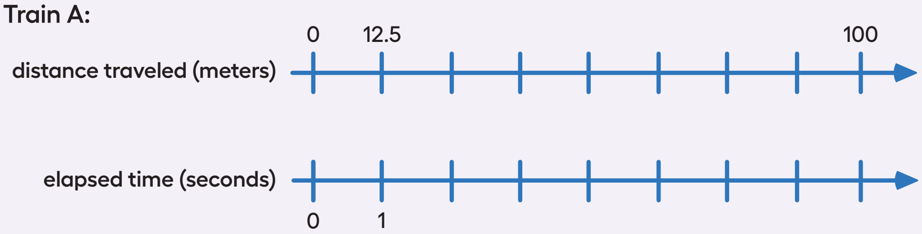
Train Speeds

5 min

Student Task Statement

Two trains are traveling at constant speeds on different tracks.

Train A:



Train B:

Which train is traveling faster? Explain your reasoning.

Train B travels faster.

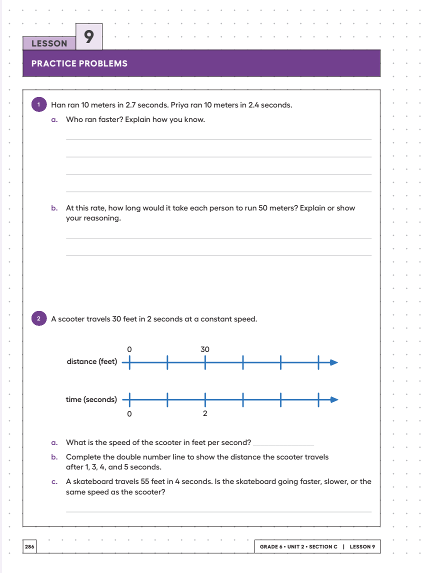
Sample reasoning:

- It only took 4 seconds for Train B to travel 100 meters, while it took Train A 8 seconds to go the same distance.
- Train B's speed is 25 meters per second. Train A's speed is 12.5 meters per second.

Practice Problems

7 Problems

Student Workbook



LESSON 9

PRACTICE PROBLEMS

1 Han ran 10 meters in 2.7 seconds. Priya ran 10 meters in 2.4 seconds.

a. Who ran faster? Explain how you know.

b. At this rate, how long would it take each person to run 50 meters? Explain or show your reasoning.

2 A scooter travels 30 feet in 2 seconds at a constant speed.

a. What is the speed of the scooter in feet per second?

b. Complete the double number line to show the distance the scooter travels after 1, 3, 4, and 5 seconds.

c. A skateboard travels 55 feet in 4 seconds. Is the skateboard going faster, slower, or the same speed as the scooter?

Problem 1

Han ran 10 meters in 2.7 seconds. Priya ran 10 meters in 2.4 seconds.

a. Who ran faster? Explain how you know.

Priya ran faster.

Sample reasoning: Priya ran the same distance (10 meters) in *less* time than Han did. This means that she was running faster.

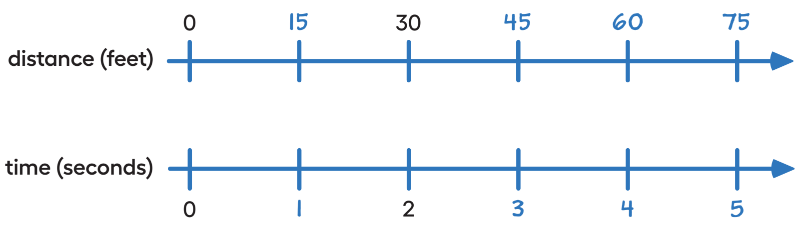
b. At this rate, how long would it take each person to run 50 meters? Explain or show your reasoning.

It would take Han 13.5 seconds and Priya 12 seconds.

Sample reasoning: Fifty meters is 5 times 10 meters, so it would take Han 5 times 2.7 seconds, which is 13.5 seconds, and it would take Priya 5 times 2.4 seconds, which is 12 seconds.

Problem 2

A scooter travels 30 feet in 2 seconds at a constant speed.



a. What is the speed of the scooter in feet per second?

15 feet per second

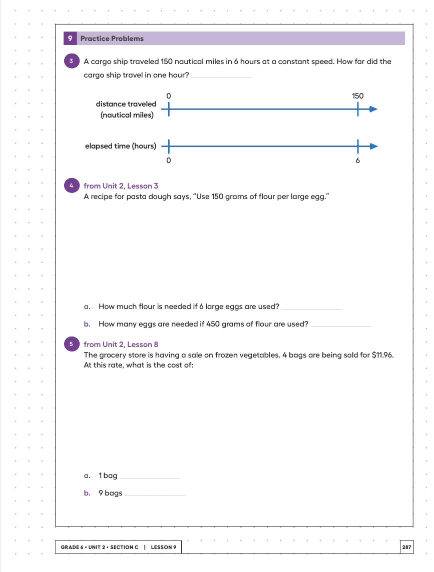
b. Complete the double number line to show the distance the scooter travels after 1, 3, 4, and 5 seconds.

c. A skateboard travels 55 feet in 4 seconds. Is the skateboard going faster, slower, or the same speed as the scooter?

slower

The scooter travels 60 feet in 4 seconds, so it is going faster than the skateboard, which travels 55 feet in 4 seconds.

Student Workbook


9 Practice Problems

3 A cargo ship traveled 150 nautical miles in 6 hours at a constant speed. How far did the cargo ship travel in one hour?

distance traveled (nautical miles) 0 150

elapsed time (hours) 0 6

4 from Unit 2, Lesson 3
A recipe for pasta dough says, "Use 150 grams of flour per large egg."

a. How much flour is needed if 6 large eggs are used?

b. How many eggs are needed if 450 grams of flour are used?

5 from Unit 2, Lesson 8
The grocery store is having a sale on frozen vegetables. 4 bags are being sold for $11.96. At this rate, what is the cost of:

a. 1 bag

b. 9 bags

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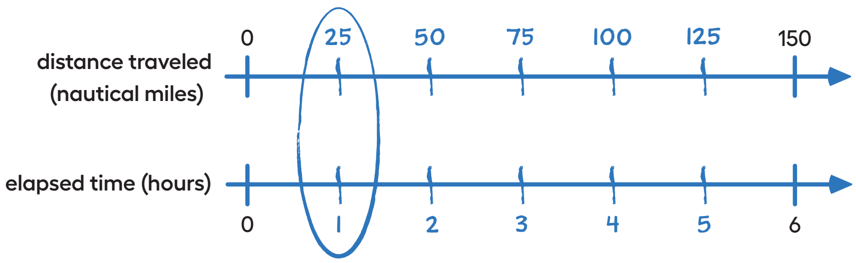
Problem 3

A cargo ship traveled 150 nautical miles in 6 hours at a constant speed. How far did the cargo ship travel in one hour?

Sample reasoning:



The ship travels 25 nautical miles in 1 hour.

Problem 4

from Unit 2, Lesson 3

A recipe for pasta dough says, “Use 150 grams of flour per large egg.”

a. How much flour is needed if 6 large eggs are used?

900 grams

b. How many eggs are needed if 450 grams of flour are used?

3 eggs

Problem 5

from Unit 2, Lesson 8

The grocery store is having a sale on frozen vegetables. 4 bags are being sold for $11.96. At this rate, what is the cost of:

a. 1 bag

$2.99

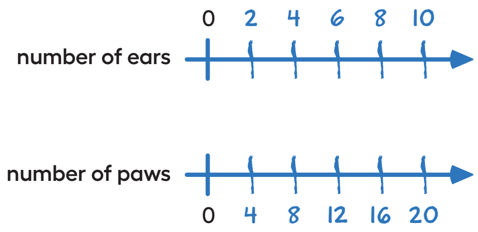
b. 9 bags

$26.91

Problem 6

from Unit 2, Lesson 7

A pet owner has 5 cats. Each cat has 2 ears and 4 paws.



a. Complete the double number line to show the numbers of ears and paws for 1, 2, 3, 4, and 5 cats.

b. If there are 3 cats in the room, what is the ratio of ears to paws?

6:12

c. If there are 4 cats in the room, what is the ratio of paws to ears?

16:8

d. If all 5 cats are in the room, how many more paws are there than ears?

10

Problem 7

from Unit 2, Lesson 5

Each of these is a pair of equivalent ratios. For each pair, explain why they are equivalent ratios or draw a representation that shows why they are equivalent ratios.

a. 5:1 and 15:3

Sample responses: Multiplying the numbers in the first ratio by 3 gives the numbers in the second ratio.

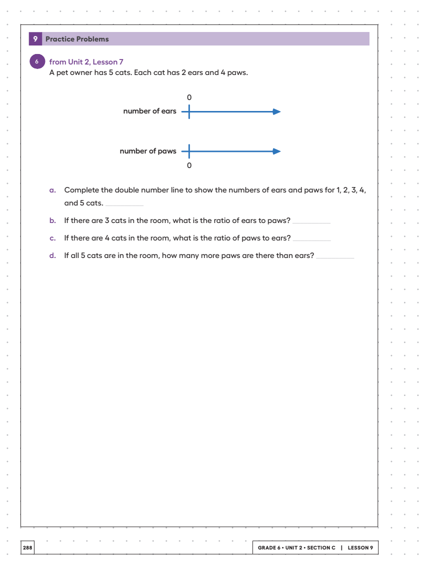
b. 25:5 and 10:2

Multiplying the numbers in the second ratio by $\frac{5}{2}$ gives the numbers in the first ratio.

c. 198:1,287 and 2:13

Multiply 2 by 99 (or 100 – 1), to get 198 (or 200 – 2), and multiply 13 by 99, to get 1,287 (1,300 – 13).

Student Workbook



Student Workbook