Lesson 13

Definition of Scientific Notation

Goals

- Identify (in writing) numbers written in scientific notation, and describe (orally) the features of an expression in scientific notation.
- Use scientific notation to represent (in writing) large and small numbers.

Learning Target

I can tell whether or not a number is written in scientific notation.

Lesson Narrative

This lesson formalizes what students have learned about writing numbers as a multiple of a power of 10 by introducing the definition of **scientific notation**. A number is said to be in **scientific notation** if it is written as a product of two factors where the first factor is a number greater than or equal to 1, but less than 10, and the second factor is an integer power of 10.

Students practice identifying numbers written in scientific notation before working with a partner to match cards that show equivalent values. Values are written as decimals, as multiples of powers of 10, or in scientific notation. When making matches, students have the opportunity to explain their thinking and critique the reasoning of others.

Student Learning Goal

Let's use scientific notation to describe large and small numbers.

Instructional Routines

- Card Sort
- Notice and Wonder
- Take Turns

Access for Multilingual Learners

- MLR8: Discussion Supports (Activity 2)

Access for Students with Diverse Abilities

- Representation (Warm-up, Activity 2)

Required Materials

Materials to Gather

- Blank paper: Lesson

Materials to Copy

- Scientific Notation Matching Cards (1 copy for every 4 students): Activity 2

Required Preparation

Lesson:
The blackline master for Scientific Notation Matching has three sets of cards. Set A is for the teacher to demonstrate the process, so only one copy of set A is needed. Cut out one set of cards (either set B or set C) for every 2 students. If possible, copy each complete set on a different color of paper to help keep them organized.

Lesson Timeline

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

Instructional Routines

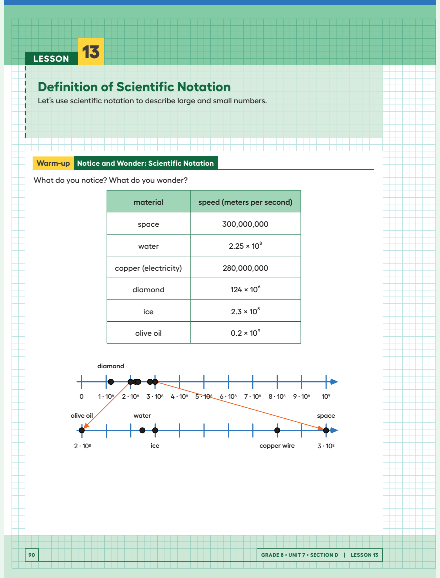
Notice and Wonder

ilclass.com/r/10694948
Please log in to the site before using the QR code or URL.

Access for Students with Diverse Abilities (Warm-up, Launch)

Representation: Internalize Comprehension.
To support working memory, provide students with sticky notes or mini whiteboards.
Supports accessibility for: Memory; Organization

Student Workbook



Warm-up

Notice and Wonder: Scientific Notation

10 min

Activity Narrative

In this activity students learn the definition of scientific notation as a way to write very large or very small numbers. Numbers can be written in scientific notation by multiplying a number between 1 and 10 by a power of 10.

Launch

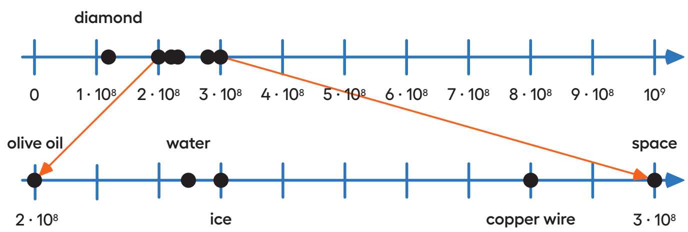
Display one problem at a time.

Give students 30 seconds of quiet think time for each problem and ask them to give a signal when they have an answer and a strategy. Keep all previous problems displayed throughout the talk. Follow with a whole-class discussion.

Student Task Statement

What do you notice? What do you wonder?

material	speed (meters per second)
space	300,000,000
water	2.25×10^8
copper (electricity)	280,000,000
diamond	124×10^6
ice	2.3×10^8
olive oil	0.2×10^9



Students may notice:

- This looks like the same set of number lines and table from a previous activity.
- The same materials that are labeled in the number lines are listed in the table.
- The tick marks of the bottom number line are not labeled.
- The speeds from the table are plotted on the number lines.
- The number lines use a dot for multiplication while the table uses an "x" for multiplication.
- Both the number lines and the table have powers of 10.

Students may wonder:

- Is this the same set of number lines and table from a previous activity?
- What is the speed of in the table?
- Why are there some unlabeled dots on the number line?
- Why do the number lines use a dot for multiplication while the table uses an "x" for multiplication?

Activity Synthesis

Ask students to share the things they noticed and wondered. Record and display their responses without editing or commentary. If possible, record the relevant reasoning on or near the image.

Next, ask students,

"Is there anything on this list that you are wondering about now?"

Encourage students to observe what is on display and respectfully ask for clarification, point out contradicting information, or voice any disagreement.

If the fact that the number lines use a dot for multiplication and the table uses an "×" for multiplication does not come up during the conversation, ask students to discuss this idea.

Tell students that this is the same number line and table from a previous activity that examined the speed of light through different materials. Direct students' attention to an unlabeled point on the number line, such as $9 \cdot 10^8$. Explain that this number is written in scientific notation — when a number is written by multiplying a number between 1 and 10 by a power of 10. For example, "9" is between 1 and 10, and 10^8 is a power of 10.

Explain that almost all books and information about scientific notation use the × symbol to indicate multiplication between the two factors, so from now on, these materials will use the × symbol in this same way. Display $9 \cdot 10^8$ for all to see, and then rewrite it as 9×10^8. Emphasize that using · is not incorrect, but that × is the most common usage.

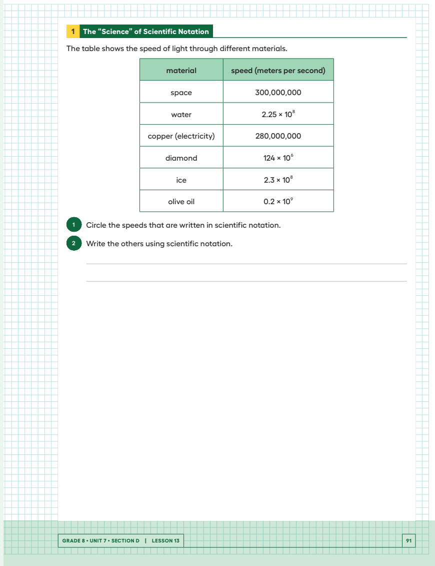
Activity 1
The "Science" of Scientific Notation

10 min

Activity Narrative

In this activity students identify expressions written in scientific notation and practice converting numbers into scientific notation. Students make use of structure to determine if a number is written in scientific notation.

Student Workbook


1 The "Science" of Scientific Notation

The table shows the speed of light through different materials.

material	speed (meters per second)
space	300,000,000
water	2.25×10^8
copper (electricity)	280,000,000
diamond	124×10^6
ice	2.3×10^8
olive oil	0.2×10^9

1. Circle the speeds that are written in scientific notation.
2. Write the others using scientific notation.

Launch

If necessary, remind students that a number is said to be in scientific notation when it is written as a product of two factors:

- The first factor is a number greater than or equal to 1, but less than 10, for example 1.2, 8, 6.35, or 2.008.
- The second factor is an integer power of 10, for example 10^8, 10^{-4}, or 10^{22}.

Display the prompt and table from the *Task Statement* for all to see. Go through the list of numbers as a class, referring to the definition as necessary to decide whether each number is written in scientific notation. When all numbers written in scientific notation have been circled, consider demonstrating or discussing how a number that was not circled could be re-written in scientific notation.

Give students 3–4 minutes of quiet work time to complete the rest of the task, and conclude with a brief whole-class discussion.

Student Task Statement

The table shows the speed of light through different materials.

material	speed (meters per second)
space	300,000,000
water	2.25×10^8
copper (electricity)	280,000,000
diamond	124×10^6
ice	2.3×10^8
olive oil	0.2×10^9

1. Circle the speeds that are written in scientific notation.
2. Write the others using scientific notation.

The following are speeds of light through each material in meters per second:

- Space: 3×10^8
- Copper: 2.8×10^8
- Diamond: 1.24×10^8
- Olive oil: 2×10^8

Activity Synthesis

The purpose of this discussion is to identify what a number written using scientific notation looks like. Begin by inviting students to share which speeds were not written using scientific notation and how they rewrote those expressions.

If necessary, emphasize that a number is said to be in scientific notation when it is written as a product of two factors:

- The first factor is a number greater than or equal to 1, but less than 10 — for example 1.2, 8, 6.35, or 2.008.
- The second factor is an integer power of 10 — for example 10^8, 10^{-4}, or 10^{22}.

Make sure that students understand how to rewrite an expression that is a multiple of a power of 10 but is not in scientific notation. Consider asking these questions using the speed of light through diamond as an example:

"Why is 124×10^6 not written in scientific notation?"

The first factor is not between 1 and 10.

"How can the first factor be rewritten so that it is between 1 and 10?"

124 can be rewritten as 1.24.

"Why can't we simply change it to 1.24×10^6?"

That would change the value of the expression.

"How can we rewrite 124 as an equivalent expression that has 1.24 in it?"

Write it as 1.24×100 or 1.24×10^2

"What is the equivalent expression in scientific notation?"

1.24×10^8, which is $(1.24 \times 10^2) \times 10^6$

If time allows, ask students to come up with at least two examples of numbers that are not in scientific notation. Select responses that highlight the fact that the first factor must be between 1 and 10 and other responses that highlight that one of the factors must be an integer power of 10.

Activity 2
Card Sort: Scientific Notation Matching

15 min

Activity Narrative

In this partner activity, students take turns matching a decimal value to an equivalent expression written as a multiple of a power of 10. As students trade roles explaining their thinking and listening, they have opportunities to explain their reasoning and critique the reasoning of others.

Launch

Tell students that the cards contain numbers written as either a decimal or as a multiple of a power of 10, and that they will take turns matching the cards. Not all cards using a power of 10 are written in scientific notation, and some of the decimal values are repeated.

Explain how to set up and do the activity. If time allows, demonstrate the steps with a student as a partner using the cards in set A. Consider demonstrating productive ways to agree or disagree, for example, by explaining your mathematical thinking or asking clarifying questions.

Arrange students in groups of 2. Give each group a set of cards from set B or set C cut from the blackline master. Tell students that not all cards using a power of 10 are written in scientific notation and that some of the decimal values are repeated.

Instructional Routines

Card Sort

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Please log in to the site before using the QR code or URL.

Instructional Routines

Take Turns

ilclass.com/r/10573524
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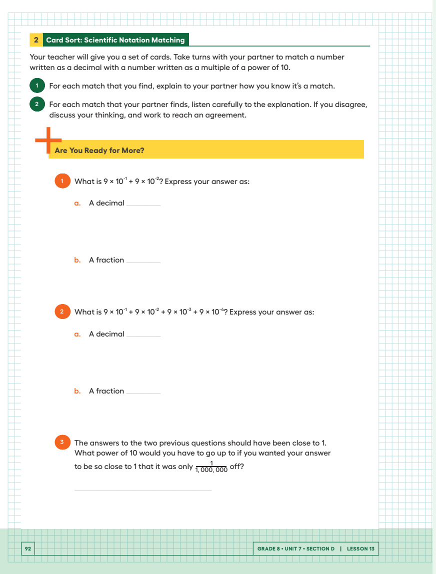
Access for Multilingual Learners (Activity 2, Student Task)

MLR8: Discussion Supports.
Students should take turns finding a match and explaining their reasoning to their partner. Display the following sentence frame for all to see: "I noticed ____, so I matched …" Encourage students to challenge each other when they disagree.
Advances: Speaking, Listening

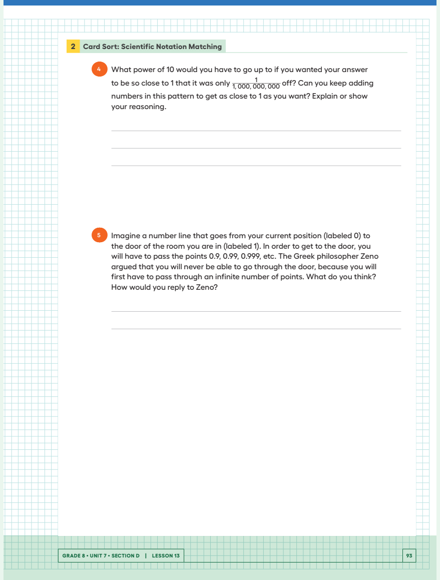
Access for Students with Diverse Abilities (Activity 2, Student Task)

Engagement: Develop Effort and Persistence.
Chunk this task into more manageable parts. Give students a subset of the cards to start with, and introduce the remaining cards once students have completed their initial set of matches.
Supports accessibility for: Conceptual Processing, Organization, Memory

Student Workbook



Student Workbook



Student Task Statement

Your teacher will give you a set of cards. Take turns with your partner to match a number written as a decimal with a number written as a multiple of a power of 10.

1. For each match that you find, explain to your partner how you know it's a match.
2. For each match that your partner finds, listen carefully to the explanation. If you disagree, discuss your thinking, and work to reach an agreement.

   The blackline master shows the correct matches — the top 12 cards correspond to the bottom 12 cards.

Are You Ready for More?

1. What is $9 \times 10^{-1} + 9 \times 10^{-2}$? Express your answer as:

   a. A decimal 0.99

   b. A fraction $\frac{99}{100}$

2. What is $9 \times 10^{-1} + 9 \times 10^{-2} + 9 \times 10^{-3} + 9 \times 10^{-4}$? Express your answer as:

   a. A decimal 0.9999

   b. A fraction $\frac{9{,}999}{10{,}000}$

3. The answers to the two previous questions should have been close to 1. What power of 10 would you have to go up to if you wanted your answer to be so close to 1 that it was only $\frac{1}{1{,}000{,}000}$ off?

   10^{-6}

4. What power of 10 would you have to go up to if you wanted your answer to be so close to 1 that it was only $\frac{1}{1{,}000{,}000{,}000}$ off?

   10^{-9}

   Can you keep adding numbers in this pattern to get as close to 1 as you want? Explain or show your reasoning

   Yes

   In the previous example, adding $9 \times 10^{-1} + \ldots + 9 \times 10^{-9}$ gave us a number that was 10^{-9} away from 1. In general, adding $9 \times 10^{-1} + \ldots + 9 \times 10^{-n}$ will be 10^{-n} away from 1, and we can choose n to make this distance as small as we want.

5. Imagine a number line that goes from your current position (labeled 0) to the door of the room you are in (labeled 1). In order to get to the door, you will have to pass the points 0.9, 0.99, 0.999, etc. The Greek philosopher Zeno argued that you will never be able to go through the door, because you will first have to pass through an infinite number of points. What do you think? How would you reply to Zeno?

   Answers vary.

   The goal is for students to think about and discuss the problem rather than coming to a substantive conclusion. Sample response: the points 0.9, 0.99, 0.999 get much closer together the farther we go in the sequence, and so the time it takes to pass each one will shrink accordingly.

Activity Synthesis

Once all groups have completed the *Card Sort*, discuss:

"Which matches were tricky? Explain why."

"Did you need to make adjustments in your matches? What might have caused an error? What adjustments were made?"

"Which cards were written in scientific notation? How do you know?"

The cards written in scientific notation have a factor that is between 1 and 10 and a factor that is a power of 10.

Lesson Synthesis

The purpose of the discussion is to practice identifying and writing numbers in scientific notation. Arrange students in groups of 2, and give each student a sheet of blank paper. Tell students to write 6 numbers on their paper in any order — 3 using scientific notation and 3 not using scientific notation. Tell students to trade papers with their partner, and to circle the numbers (on the paper that they received) that are written in scientific notation. Tell students to check their partner's work and discuss any disagreements. Here are some additional questions for discussion. Consider displaying student responses for all to see.

"What are some examples of expressions that are in scientific notation? How can you tell they are in scientific notation?"

Expressions vary.

They are in scientific notation because the first factor is between 1 and 10 and the other factor is a power of 10.

"What are some examples of expressions that are not in scientific notation?"

Answers vary.

"How would you write a very small number like 0.000021 in scientific notation?"

2.1×10^{-5}

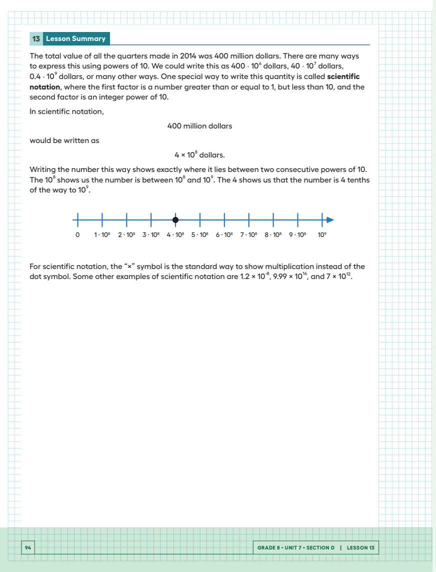
"How would you write a very large number like 21,000,000 in scientific notation?"

2.1×10^{7}

"Why might scientific notation be useful?"

"Can you think of information in the real world that might be easier to work with in scientific notation?"

Student Workbook



Responding To Student Thinking

More Chances
Students will have more opportunities to understand the mathematical ideas in this *Cool-down*, so there is no need to slow down or add additional work to the next lessons.

Lesson Summary

The total value of all the quarters made in 2014 was 400 million dollars. There are many ways to express this using powers of 10. We could write this as $400 \cdot 10^6$ dollars, $40 \cdot 10^7$ dollars, $0.4 \cdot 10^9$ dollars, or many other ways. One special way to write this quantity is called **scientific notation**, where the first factor is a number greater than or equal to 1, but less than 10, and the second factor is an integer power of 10.

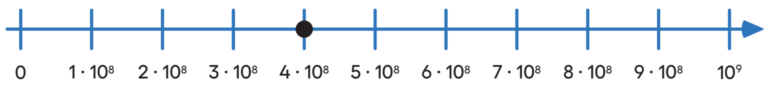
In scientific notation,

400 million dollars

would be written as

4×10^8 dollars.

Writing the number this way shows exactly where it lies between two consecutive powers of 10. The 10^8 shows us the number is between 10^8 and 10^9. The 4 shows us that the number is 4 tenths of the way to 10^9.



For scientific notation, the "×" symbol is the standard way to show multiplication instead of the dot symbol. Some other examples of scientific notation are 1.2×10^{-8}, 9.99×10^{16}, and 7×10^{12}.

Cool-down

Scientific Notation Check

5 min

Students convert numbers to scientific notation.

Student Task Statement

Determine which of the following numbers are written in scientific notation. If a number is not, write it in scientific notation.

1. 5.23×10^8

   Already in scientific notation

2. 48,200

   4.82×10^4

3. 0.00099

   9.9×10^{-4}

4. 36×10^5

   3.6×10^6

5. 8.7×10^{-12}

   Already in scientific notation

6. 0.78×10^{-3}

   7.8×10^{-4}

Lesson **13**

Practice Problems

5 Problems

Problem 1

Write each number in scientific notation.

a. 14,700 1.47×10^{4}

b. 0.00083 8.3×10^{-4}

c. 760,000,000 7.6×10^{8}

d. 0.038 3.8×10^{-2}

e. 0.38 3.8×10^{-1}

f. 3.8 3.8×10^{0}

g. 3,800,000,000,000 3.8×10^{12}

h. 0.0000000009 9×10^{-10}

Problem 2

Elena is going to write the number 0.0000025 in scientific notation. She writes "$2.5 \times 10^{?}$" but isn't sure what to write for the exponent. Explain how Elena can decide which power of 10 to use.

Sample response: Elena should use 10^{-6} since 2.5×10^{-1} is 0.25 and 2.5×10^{-2} is 0.025. That means the number of zeros after the decimal point should be one less than the number after the negative sign. Since there are five zeros after the decimal point, the number after the negative sign should be a "6," and the expression would be $0.0000025 = 2.5 \times 10^{-6}$

Problem 3

The following numbers are all written in scientific notation. Write the value of each expression.

a. 8.5×10^{6} 8,500,000

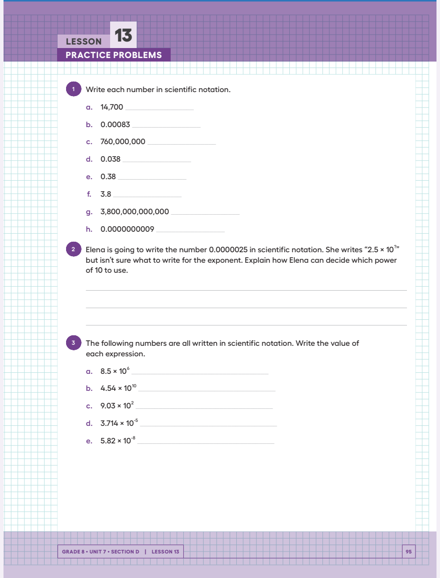
b. 4.54×10^{10} 45,400,000,000

c. 9.03×10^{2} 903

d. 3.714×10^{-5} 0.00003714

e. 5.82×10^{-8} 0.0000000582

Student Workbook


LESSON 13
PRACTICE PROBLEMS

1 Write each number in scientific notation.

a. 14,700
b. 0.00083
c. 760,000,000
d. 0.038
e. 0.38
f. 3.8
g. 3,800,000,000,000
h. 0.0000000009

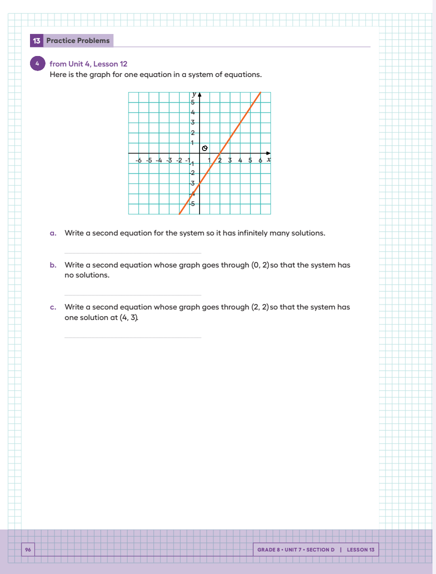
2 Elena is going to write the number 0.0000025 in scientific notation. She writes "$2.5 \times 10^{?}$" but isn't sure what to write for the exponent. Explain how Elena can decide which power of 10 to use.

3 The following numbers are all written in scientific notation. Write the value of each expression.

a. 8.5×10^{6}
b. 4.54×10^{10}
c. 9.03×10^{2}
d. 3.714×10^{-5}
e. 5.82×10^{-8}

GRADE 8 • UNIT 7 • SECTION D | LESSON 13 95

Student Workbook


13 Practice Problems

4 from Unit 4, Lesson 12

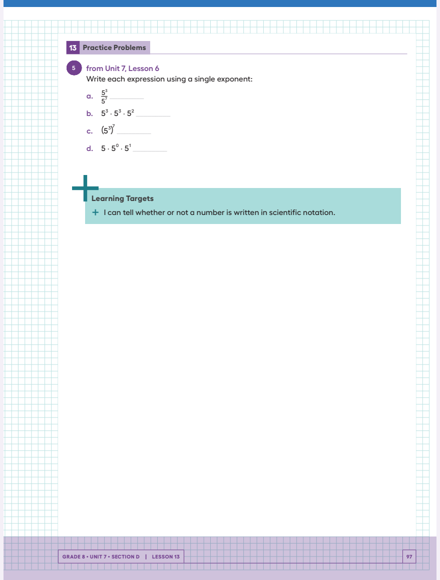
Here is the graph for one equation in a system of equations.

a. Write a second equation for the system so it has infinitely many solutions.

b. Write a second equation whose graph goes through (0, 2) so that the system has no solutions.

c. Write a second equation whose graph goes through (2, 2) so that the system has one solution at (4, 3).

Student Workbook


13 Practice Problems

5 from Unit 7, Lesson 6

Write each expression using a single exponent:

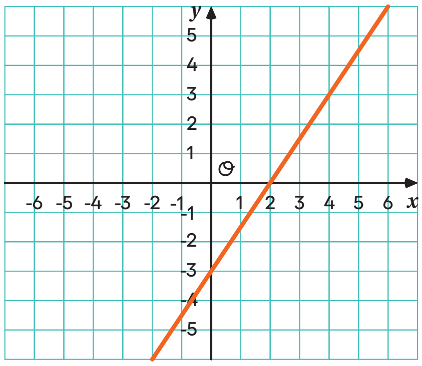
Learning Targets

+ I can tell whether or not a number is written in scientific notation.

Problem 4

from Unit 4, Lesson 12

Here is the graph for one equation in a system of equations.



a. Write a second equation for the system so it has infinitely many solutions.

$y = \frac{3}{2}x - 3$ (or equivalent)

b. Write a second equation whose graph goes through (0, 2) so that the system has no solutions.

$y = \frac{3}{2}x + 2$ (or equivalent)

c. Write a second equation whose graph goes through (2, 2) so that the system has one solution at (4, 3).

$y = \frac{1}{2}x + 1$ (or equivalent)

Problem 5

from Unit 7, Lesson 6

Write each expression using a single exponent:

a. $\frac{5^3}{5^7}$ 5^{-4}

b. $5^3 \cdot 5^3 \cdot 5^2$ 5^8

c. $(5^3)^7$ 5^{21}

d. $5 \cdot 5^0 \cdot 5^1$ 5^2