

### Explore It!

The number line shows the movement of a glacier that retreats 8 meters every year.

position 4 years from now

position now

position 4 years ago

**A.** How could you use division to represent the yearly change in the glacier's position over the next 4 years?

**B.** How could you use division to represent the yearly change in the glacier's position over the past 4 years?

**C.** Suppose the glacier retreated 8.25 meters every year. Draw a number line to represent this movement.

#### Lesson 1-9

### Divide Rational Numbers

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**I can...**  
divide rational numbers.

#### Focus on math practices

**Reasoning** If the number of meters the glacier retreats each year changes, does it affect the signs of each part of the division statement in Part A? Explain.

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### Essential Question

How is dividing rational numbers like dividing integers?

**EXAMPLE 1** Divide a Negative Number by a Positive Rational Number

Yumiko has a drip hose attached to a rain barrel for her garden. The water drains from the rain barrel at a constant rate. What is the change in the volume of water after 1 minute?

**Make Sense and Persevere** Start by estimating the change in the volume of water after 1 minute.

Use a number line to represent the change in the volume.

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Use the rules for multiplication.

$$-3\frac{3}{5} \div 6$$

$$= -\frac{18}{5} \cdot \frac{1}{6}$$

$$= -\frac{18}{5} \cdot \frac{1}{6}$$

$$= -\frac{18}{30}$$

So, the change in the volume of water after 1 minute is  $-\frac{3}{5}$  gallon.

**Generalize** You can extend what you know about multiplying rational numbers and dividing integers to division of rational numbers.

**Try It!**

Suppose that the volume of water in the rain barrel decreased by  $\frac{4}{8}$  gallons in 4 minutes. What will be the change in the volume of water after 1 minute?

The rain barrel will lose  gallons in 1 minute.

**Convince Me!** How are multiplicative inverses used in division with rational numbers?

$$\frac{\square}{8} \div \frac{4}{1}$$

$$= \frac{\square}{8} \cdot \square$$

$$= \frac{\square}{32}, \text{ or } -\frac{\square}{32}$$

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**EXAMPLE 2** Divide a Positive Number by a Negative Rational Number

Simplify  $\frac{3\frac{2}{3}}{-\frac{2}{3}}$

A **complex fraction** has a fraction in the numerator, the denominator, or both.

$3\frac{2}{3} \div \left(-\frac{2}{3}\right)$   
 $= \frac{11}{3} \div \left(-\frac{2}{3}\right)$   
 $= \frac{11}{3} \cdot \left(-\frac{3}{2}\right)$   
 $= \frac{11 \cdot (-3)}{3 \cdot 2}$   
 $= -\frac{33}{6} = -\frac{11}{2}$   
 $= -5\frac{1}{2}$

The multiplicative inverse of  $-\frac{2}{3}$  is  $-\frac{3}{2}$  because  $-\frac{2}{3} \cdot -\frac{3}{2} = 1$ .

**Try It!** Find each quotient.

a.  $\frac{1\frac{2}{5}}{\frac{1}{5}}$       b.  $-0.4 \div 0.25$       c.  $\frac{7}{6} \div \frac{3}{4}$       d.  $0.7 \div -1\frac{1}{6}$

**EXAMPLE 3** Divide Rational Numbers with the Same Sign

The location of a submarine changes by  $-0.06$  kilometer each minute. How much time does it take to get to the sea bottom?

$-\frac{3}{4} \div (-0.06)$   
 $= -0.75 \div (-0.06)$   
 $= 12.5$

Divide the location of the sea bottom by the change in the location of the submarine.

The rules for dividing integers apply to all rational numbers.  
**negative  $\div$  negative = positive**

It takes 12.5 minutes to reach the sea bottom.

**Try It!** Find each quotient.

a.  $-1\frac{1}{3} \div (-1.6)$       b.  $-\frac{3}{4} \div \frac{1}{4}$       c.  $-\frac{9}{10} \div \left(-\frac{3}{10}\right)$       d.  $-0.5 \div \left(-\frac{3}{13}\right)$

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**KEY CONCEPT**

The same rules for dividing integers apply to dividing rational numbers. When dividing two rational numbers:

- If the signs of the dividend and divisor are the same, the quotient is positive.
- If the signs of the dividend and divisor are different, the quotient is negative.

**Do You Understand?**

1. **Communicate** How is dividing rational numbers like dividing integers?

2. **Use Structure** How do you know the sign of the quotient  $-\frac{4}{5} \div \frac{2}{3}$ ?

3. **Reasoning** When  $-4$  is divided by a rational number between 0 and 1, where would the quotient be located on the number line? Why?

**Do You Know How?**

4. Find each quotient.

a.  $-\frac{7}{12} \div \left(-\frac{1}{7}\right)$       b.  $-0.05 \div (-3)$       c.  $6\frac{1}{2} \div \left(-\frac{1}{5}\right)$       d.  $-1 \div \left(-\frac{10}{11}\right)$

5. Simplify the complex fraction.

a.  $\frac{\frac{1}{2} \div \frac{1}{3}}{\frac{1}{4} \div \frac{1}{5}}$       b.  $\frac{\frac{1}{2} \div \frac{1}{3}}{\frac{1}{4} \div \frac{1}{5}}$       c.  $\frac{\frac{1}{2} \div \frac{1}{3}}{\frac{1}{4} \div \frac{1}{5}}$

*Handwritten notes:*

- "flip" reciprocal or multiplicative inverse
- $-\frac{7}{12} \div \left(-\frac{1}{7}\right) \rightarrow \frac{7}{12} \times \frac{7}{1} = \frac{49}{12} \rightarrow 4\frac{1}{12}$
- $-0.05 \div (-3) \rightarrow \frac{-0.05}{-3} = \frac{0.05}{3} = \frac{5}{600} = \frac{1}{120}$
- $6\frac{1}{2} \div \left(-\frac{1}{5}\right) \rightarrow -7.7 \div \frac{1}{5} \rightarrow -7.7 \times 5 = -38.5$
- $-1 \div \left(-\frac{10}{11}\right) \rightarrow 1 \times \frac{11}{10} = \frac{11}{10} = 1\frac{1}{10}$
- $\frac{\frac{1}{2} \div \frac{1}{3}}{\frac{1}{4} \div \frac{1}{5}} \rightarrow \frac{\frac{1}{2} \times \frac{3}{1}}{\frac{1}{4} \times \frac{5}{1}} = \frac{\frac{3}{2}}{\frac{5}{4}} = \frac{3}{2} \times \frac{4}{5} = \frac{12}{10} = \frac{6}{5} = 1\frac{1}{5}$
- $-\frac{4}{5} \div \frac{2}{3} \rightarrow -\frac{4}{5} \times \frac{3}{2} = -\frac{12}{10} = -\frac{6}{5} = -1\frac{1}{5}$
- $-\frac{9}{10} \div \left(-\frac{8}{5}\right) \rightarrow \frac{9}{10} \times \frac{5}{8} = \frac{45}{80} = \frac{9}{16}$
- $-\frac{9}{10} \div \frac{8}{5} \rightarrow -\frac{9}{10} \times \frac{5}{8} = -\frac{45}{80} = -\frac{9}{16}$  (\*negative answer)

Name: \_\_\_\_\_

### Practice & Problem Solving

Leveled Practice In 6-7, fill in the boxes to find the quotient.

6. Find the quotient  $\frac{2}{3} \div (-\frac{11}{5})$ .

$$\frac{2}{3} \div (-\frac{11}{5}) = \frac{2}{3} \cdot \frac{5}{-11} = \frac{10}{-33} = -\frac{10}{33}$$

7. Simplify the complex fraction  $\frac{-\frac{4}{10}}{\frac{1}{10}}$ .

Rewrite the complex fraction:  $\frac{-\frac{4}{10}}{\frac{1}{10}} = \frac{-\frac{4}{10} \cdot \frac{10}{10}}{\frac{1}{10} \cdot \frac{10}{10}} = \frac{-4}{1}$

Write the division as multiplication:  $\frac{-4}{1} \cdot \frac{10}{10} = -4$

The product is:  $-4$

8. Which multiplication expression is equivalent to the division expression  $\frac{-7}{17} \div \frac{13}{34}$ ?

Ⓐ  $-\frac{7}{17} \times \frac{13}{34}$       Ⓒ  $-\frac{7}{17} \times \frac{34}{13}$   
 Ⓑ  $-\frac{7}{17} \times \frac{13}{34}$       Ⓓ  $-\frac{7}{17} \times \frac{34}{13}$

9. Derek says that the quotient  $\frac{-2}{7} \div (-\frac{2}{21})$  is  $-\frac{3}{7}$ .

a. What is the correct quotient?  
 b. What mistake did Derek likely make?

10. The water level of a lake fell by  $1\frac{1}{2}$  inches during a  $\frac{1}{3}$ -week-long dry spell. Simplify the complex fraction below to find the average rate at which the water level changed every week.

$$\frac{-1\frac{1}{2}}{\frac{1}{3}} \text{ inches/week} = \frac{-\frac{3}{2}}{\frac{1}{3}} = -\frac{3}{2} \cdot \frac{3}{1} = -\frac{9}{2} = -4\frac{1}{2} \text{ inches/week}$$

11. Complete the table. Simplify expressions.

Dividend	Divisor	Quotient
a. $-\frac{3}{4}$	$\div \frac{2}{5}$	<input type="text"/>
b. $-0.75$	$\div 0.4$	<input type="text"/>
c. $\frac{3}{4}$	$\div \frac{1}{2}$	<input type="text"/>

12. a. Find the reciprocal of  $-\frac{1}{7}$ .  
 b. Find the reciprocal of  $\frac{17}{18}$ .  
 c. Reasoning Explain why the answer for part a is the multiplicative inverse of the answer for part b.

Handwritten work for problem 9:

$$\frac{-2}{7} \div (-\frac{2}{21}) = \frac{-2}{7} \cdot \frac{21}{-2} = \frac{-2 \cdot 21}{7 \cdot -2} = \frac{-42}{-14} = 3$$

Answers: a. 3, b. He forgot to flip the divisor.

Handwritten work for problem 11c:

$$\frac{3}{4} \div \frac{1}{2} = \frac{3}{4} \cdot \frac{2}{1} = \frac{6}{4} = \frac{3}{2}$$

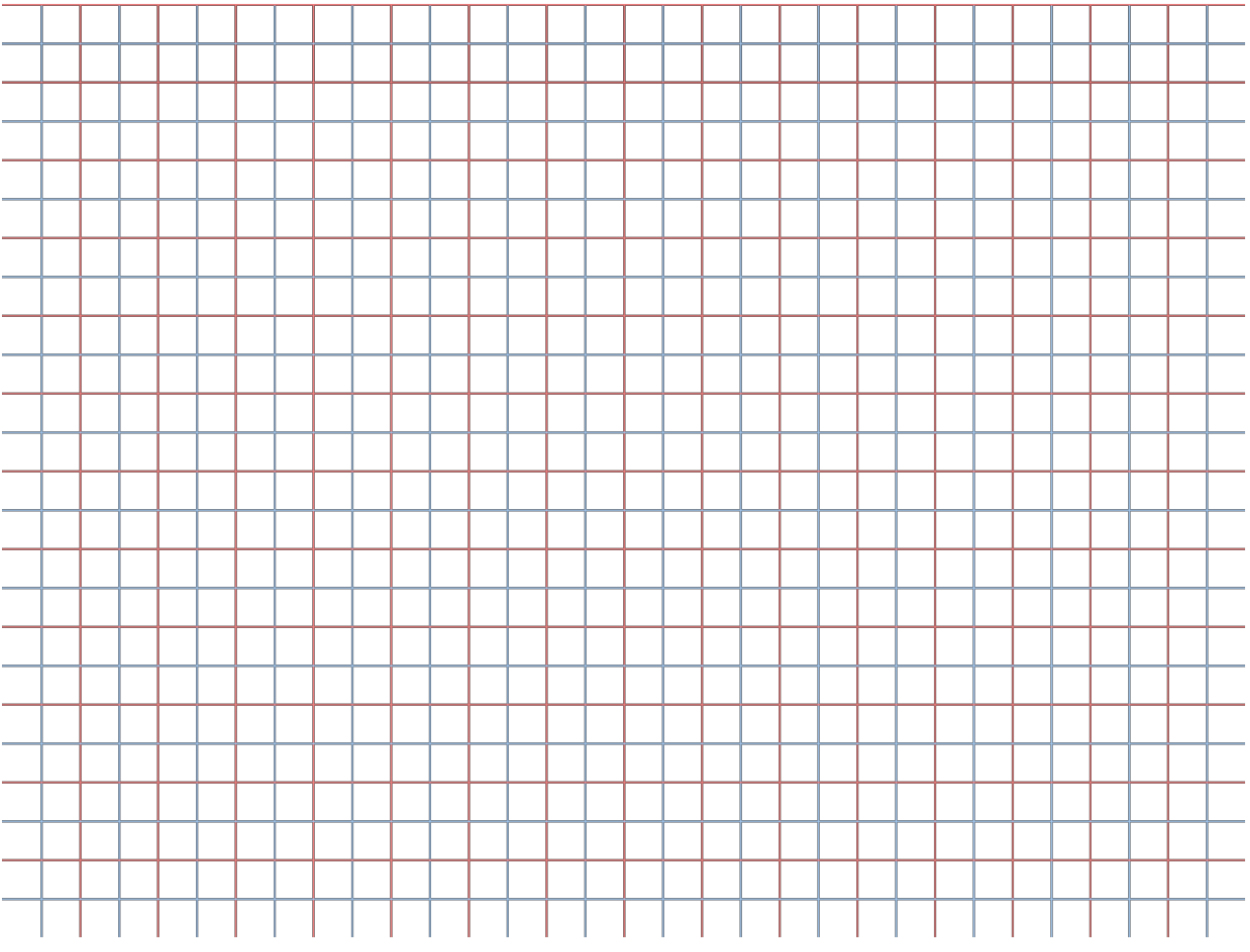
Handwritten work for problem 12c:

$$\frac{1}{7} \cdot \frac{7}{7} = \frac{7}{7} = 1$$

$$\frac{17}{18} \cdot \frac{18}{18} = \frac{18}{18} = 1$$

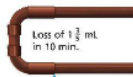
Handwritten work for problem 11b:

$$-0.75 \div 0.4 = \frac{-0.75}{0.4} = \frac{-75}{40} = \frac{-15}{8} = -1\frac{7}{8}$$



13. Use numbers  $-\frac{7}{13}$ ,  $1\frac{6}{7}$ ,  $-1\frac{6}{7}$ ,  $\frac{7}{13}$
- Which is the reciprocal of  $1\frac{6}{7}$ ?
  - Which is the reciprocal of  $\frac{7}{13}$ ?
- c. **Reasoning** What do you notice about the reciprocals of  $1\frac{6}{7}$  and  $\frac{7}{13}$ ?

14. A water tank in Stewart's home had a small, steady leak.



a. Use a complex fraction to represent the change in the volume of water in 1 minute.

milliliters  
10 minutes



b. Simplify the complex fraction to find the change in the volume of water in the tank in 1 minute.

15. Find the quotient. Express your answer as a simplified fraction.

$$\frac{3}{10} \div 3.8$$

16. **Higher Order Thinking** Between 10 P.M. and 7:45 A.M., the water level in a swimming pool decreased by  $\frac{13}{16}$  inch.

Assuming that the water level decreased at a constant rate, how much did it drop each hour? The water level decreased by  inch each hour.

recip.  
 $-\frac{3}{10}$

$-1\frac{3}{7} = -\frac{10}{3}$

17. **Critique Reasoning** Kayla wants to find  $2\frac{2}{3} \div (-1\frac{3}{7})$ . She first rewrites the division as  $(\frac{22}{3}) \div (-\frac{13}{7})$ . What is wrong with Kayla's reasoning?

Kayla needs to change the mixed numbers into improper fractions before she "flips" the second fraction.

**Assessment Practice**

18. Which is an equivalent multiplication expression for  $(-\frac{3}{8}) \cdot 7$ ?

$-\frac{3}{8} \cdot (\frac{7}{54})$

$-\frac{3}{8} \cdot (\frac{7}{54})$

$-\frac{3}{8} \cdot (-\frac{54}{7})$

$-\frac{3}{8} \cdot (\frac{54}{7})$

$-\frac{8}{3} \cdot (-\frac{7}{54})$

19. Divide  $-\frac{2}{3} \div \frac{6}{5}$ . Explain each step you used to find the quotient.

