

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.

Scan for Multimedia

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?

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

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

$$= -\frac{\square}{32}, \text{ or } -1\frac{\square}{32}$$

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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.

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

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. $0.7 \div -1\frac{1}{6}$

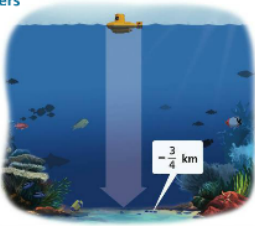
EXAMPLE 3 Divide Rational Numbers with the Same Sign

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

$$\begin{aligned} & -\frac{3}{4} \div (-0.06) \\ &= -0.75 \div (-0.06) \\ &= 12.5 \end{aligned}$$

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?

- Reasoning How is dividing rational numbers like dividing integers?
- Use Structure How do you know the sign of the quotient $-\frac{3}{5} \div \frac{1}{2}$?
- 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?

- Find each quotient.
 - a. $-\frac{7}{12} \div \frac{1}{7}$
 - b. $-0.05 \div \left(-\frac{2}{3}\right)$
 - c. $\frac{1}{2} \div \left(-\frac{3}{4}\right)$
 - d. $-1 \div \left(-\frac{11}{12}\right)$
- Simplify the complex fraction: $\frac{-4\frac{9}{12}}{\frac{1}{12}}$

Handwritten notes and calculations:

"flip" "reciprocal" "multiplicative inverse"

$$-\frac{7}{12} \div \frac{1}{7} \rightarrow -\frac{7}{12} \times \frac{7}{1} = -\frac{49}{12} = 4\frac{1}{12}$$

$$-0.05 \div \left(-\frac{2}{3}\right) = \frac{-0.05}{1} \times \frac{3}{-2} = \frac{-0.15}{-2} = 0.075$$

$$\frac{1}{2} \div \left(-\frac{3}{4}\right) = \frac{1}{2} \times \frac{4}{-3} = \frac{4}{-6} = -\frac{2}{3}$$

$$-1 \div \left(-\frac{11}{12}\right) = -1 \times \frac{12}{-11} = \frac{12}{11}$$

$$\frac{-4\frac{9}{12}}{\frac{1}{12}} = \frac{-4\frac{9}{12} \cdot 12}{\frac{1}{12} \cdot 12} = \frac{-49}{1} = -49$$

$$-\frac{3}{5} \div \frac{1}{2} = -\frac{3}{5} \times \frac{2}{1} = -\frac{6}{5} = -1\frac{1}{5}$$

$$-\frac{3}{5} \div \frac{9}{4} = -\frac{3}{5} \times \frac{4}{9} = -\frac{12}{45} = -\frac{4}{15}$$

Name: _____

Practice & Problem Solving

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

6. Find the quotient $\frac{5}{7} \div (-\frac{11}{13})$.

$$\frac{5}{7} \div (-\frac{11}{13}) = \frac{5}{7} \cdot \frac{13}{-11} = \frac{65}{-77} = -\frac{65}{77}$$

7. Simplify the complex fraction $\frac{\frac{4}{10}}{\frac{3}{5}}$.

Rewrite the complex fraction: $\frac{4}{10} \div \frac{3}{5}$

Write the division as multiplication: $\frac{4}{10} \cdot \frac{5}{3}$

The product is $\frac{4 \cdot 5}{10 \cdot 3} = \frac{20}{30} = \frac{2}{3}$

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

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

9. Derek says that the quotient $-\frac{2}{7} \div (-\frac{2}{21})$ is $-\frac{1}{3}$.

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 $\frac{1}{2}$ -week-long dry spell. Simplify the complex fraction below and find the average rate at which the water level changed each week.

$-\frac{1\frac{1}{2}}{\frac{1}{2}}$ inches/week

11. Complete the table. Simplify expressions.

	Dividend	Divisor	Quotient
a.	$-\frac{3}{4}$	$\frac{2}{5}$	
b.	-0.75	0.4	
c.	$\frac{3}{4}$	$-\frac{2}{5}$	

12. a. Find the reciprocal of $-\frac{4}{17}$.
 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.

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Keep, change, ÷ to × (flip)

$-\frac{1}{2} \div \frac{1}{3} = -\frac{1}{2} \times \frac{3}{1} = -\frac{3}{2} = -1\frac{1}{2}$ see notes



$-\frac{4 \cdot 2}{1 \cdot 3} = -\frac{8}{3}$

$3 \overline{) -8} \begin{array}{r} 2 \\ -6 \\ \hline -2 \end{array}$

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

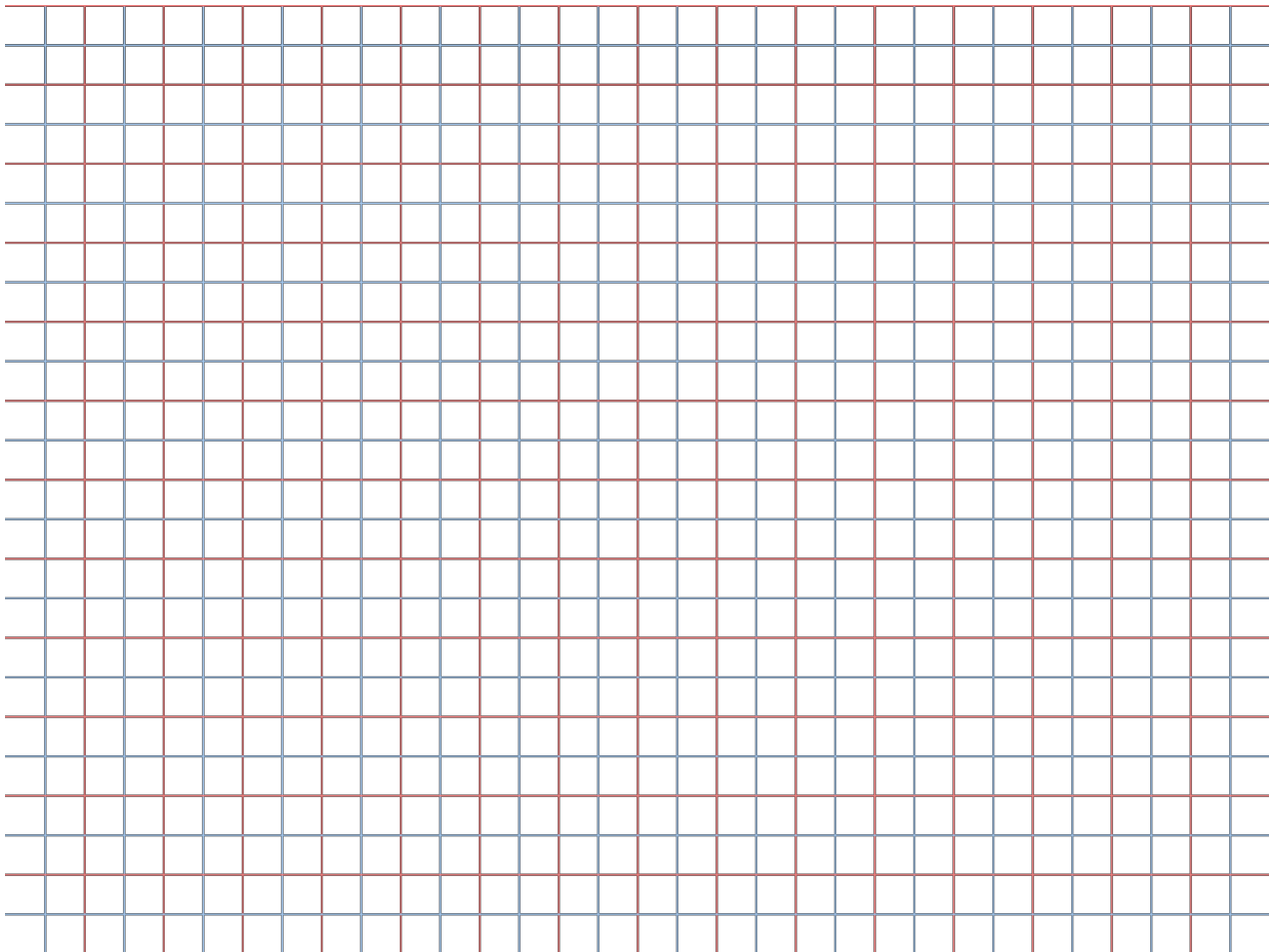
10) $\frac{-3}{2} \div \frac{5}{3}$

$\frac{-3}{2} \times \frac{3}{5}$

$\frac{-3 \cdot 3}{2 \cdot 5}$

$-\frac{9}{10}$

The water level dropped an average of $\frac{9}{10}$ in each week.



13. Use numbers $-\frac{7}{13}$, $\frac{13}{7}$, $-\frac{7}{13}$

a. Which is the reciprocal of $\frac{13}{7}$? $\frac{7}{13}$

b. Which is the reciprocal of $\frac{7}{13}$? $\frac{13}{7}$

c. Reasoning What do you notice about the reciprocals of $\frac{13}{7}$ and $\frac{7}{13}$?
 Each value is the reciprocal of the other.
 $\frac{13}{7} = \frac{1}{\frac{7}{13}}$

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.
 Loss of $\frac{1}{3}$ qt. in 10 min.
 $\frac{\frac{1}{3} \text{ qt.}}{10 \text{ min.}}$

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.
 $\frac{3}{10} \div \frac{2}{8}$

16. Higher Order Thinking Between 10 a.m. and 7:45 a.m., the water level in a swimming pool decreased by $\frac{3}{16}$ inch. Assuming that the water level decreased at a constant rate, how much did it drop each hour? The water level decreased by $\frac{1}{4}$ inch each hour.

17. Critical Reasoning Kayla wants to find $2\frac{1}{2} \div (-\frac{1}{3})$. She first rewrites the division as $(\frac{5}{2}) \div (-\frac{1}{3})$. What is wrong with Kayla's reasoning?

Assessment Practice

18. Which is an equivalent multiplication expression for $\frac{1}{(-\frac{1}{2})}$?
- $\frac{1}{2} \cdot (\frac{2}{1})$
 - $\frac{1}{2} \cdot (\frac{1}{2})$
 - $\frac{1}{2} \cdot (-\frac{2}{1})$
 - $\frac{1}{2} \cdot (-\frac{1}{2})$
19. Divide $-\frac{2}{3} \div \frac{4}{5}$. Explain each step you used to find the quotient.

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

$$-\frac{3}{8} \times -\frac{54}{7}$$

