

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.

Use the rules for multiplication.

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

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

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

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

Two numbers whose product is 1 are **multiplicative inverses**, or reciprocals.

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.

Scan for Multimedia

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

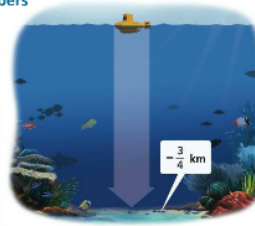
EXAMPLE 3 Divide Rational Numbers with the Same Sign

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. $-\frac{2}{4} \div -\frac{3}{4}$ c. $-\frac{9}{10} \div \left(-\frac{3}{10}\right)$ d. $-0.5 \div \left(-\frac{3}{13}\right)$

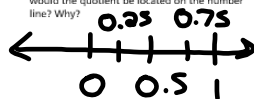
KEY CONCEPT

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?

- Essential Question** How is dividing rational numbers like dividing integers?
- Use Structure** How do you know the sign of the quotient $-\frac{4}{5} \div \frac{1}{6}$?
- Reasoning** When -4 is divided by a rational number between 0 and 1, where would the quotient be located on the number line? Why?



$$\frac{-40}{0.5} = -\frac{40}{\frac{1}{2}} = -80$$

Do You Know How?

4. Find each quotient.

a. $-\frac{7}{12} \div \frac{1}{1}$ $\rightarrow -\frac{7}{12} \times \frac{7}{1} \rightarrow -\frac{49}{12}$

b. $-0.05 \div \left(-\frac{5}{8}\right)$

c. $6\frac{1}{4} \div \left(-\frac{5}{16}\right)$

d. $-1 \div \left(-\frac{10}{13}\right)$

5. Simplify the complex fraction

a. $\frac{1\frac{1}{2}}{\frac{2}{3}}$ $\rightarrow \frac{3}{2} \div \frac{1\frac{1}{3}}{3} \rightarrow \frac{4}{3}$

b. $2\frac{1}{4} \div \frac{3}{4}$ $\rightarrow \frac{9}{2} \times \frac{3}{4} = \frac{27}{8}$

c. $\frac{1\frac{1}{2}}{2\frac{1}{10}}$ $\rightarrow \frac{3}{2} \times \frac{10}{21} = \frac{5}{7}$

$$\frac{-3}{14}$$

Practice & Problem Solving

6. Find the quotient $\frac{3}{4} \div (-\frac{1}{2})$.

7. Simplify the complex fraction $\frac{\frac{1}{2}}{\frac{3}{4}}$.

8. Which multiplication expression is equivalent to the division expression $-\frac{2}{3} \div \frac{4}{5}$?

9. Derek says that the quotient $\frac{3}{4} \div (-\frac{1}{2})$ is $-\frac{3}{2}$.

10. The water level of a lake fell by $\frac{1}{4}$ inches during a $\frac{1}{2}$ week long dry spell. Simplify the complex fraction below to find the average rate at which the water level changed every week.

11. Complete the table. Simplify expressions.

Division	Divisor	Quotient
a. $-\frac{1}{2} \div \frac{2}{3}$	$\frac{2}{3}$	
b. $-0.75 \div 0.4$	0.4	
c. $\frac{2}{3} \div -\frac{1}{2}$	$-\frac{1}{2}$	

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

see notes

$-\frac{0.75}{0.4} = \frac{-7.5}{4}$

$\frac{-7.5}{4} = \frac{-7.500000}{4}$

$$\begin{array}{r} 1.875 \\ 4 \overline{) -7.500000} \\ \underline{-4} \\ -3.500000 \\ \underline{-3} \\ -0.500000 \\ \underline{-0} \\ -0.500000 \\ \underline{-0} \\ -0.500000 \\ \underline{-0} \\ -0.500000 \\ \underline{-0} \\ -0.500000 \\ \underline{-0} \\ -0.500000 \\ \underline{-0} \\ 0 \end{array}$$

reciprocal is $-\frac{18}{17}$

reciprocal is $-\frac{17}{18}$

$-\frac{17}{18} \div \frac{17}{18} = \frac{-17 \div 17}{18 \div 18} = \frac{-1}{1} = -1$

$-\frac{18}{17} \div -\frac{17}{18} = \frac{-18 \div -17}{17 \div 18} = \frac{+1}{1} = +1$

A number multiplied by its reciprocal i.e. multiplicative inverse equals +1

10)
$$\frac{-1\frac{1}{2}}{1\frac{2}{3}} = -\frac{2\frac{1}{2}}{2\frac{2}{3}} \div \frac{2\frac{1}{2}}{2\frac{2}{3}}$$

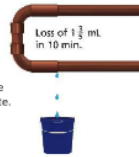
$$-\frac{3}{2} \div \frac{5}{3}$$

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

$$-\frac{9}{10}$$

13. Use numbers $-\frac{7}{13}$, $1\frac{5}{7}$, $-1\frac{5}{7}$, $\frac{7}{13}$
- Which is the reciprocal of $1\frac{5}{7}$?
 - Which is the reciprocal of $\frac{7}{13}$?
 - Reasoning** What do you notice about the reciprocals of $1\frac{5}{7}$ and $\frac{7}{13}$?

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



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

milliliters
10 minutes

- 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 $\frac{3}{16}$ inch.

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

The water level decreased by inch each hour.

17. **Critique Reasoning** Kayla wants to find $2\frac{2}{3} \div (-1\frac{3}{7})$. She first rewrites the division as $(\frac{23}{3}) \div (-\frac{13}{7})$. What is wrong with Kayla's reasoning?

$$-1\frac{2}{3} \rightarrow -\frac{10}{3}$$

$$\frac{23}{3} \div (-\frac{13}{7})$$

$$\frac{8}{3} \div \frac{-10}{7}$$

Assessment Practice

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

- Ⓐ $-\frac{3}{8} \cdot (\frac{7}{54})$ Ⓒ $-\frac{3}{8} \cdot (\frac{54}{7})$
 Ⓑ $-\frac{3}{8} \cdot (-\frac{54}{7})$ Ⓓ $-\frac{8}{3} \cdot (-\frac{7}{54})$

19. Divide $-2\frac{3}{8} \div \frac{6}{5}$. Explain each step you used to find the quotient.

