Lesson 2-8
Use Powers of 10 to Estimate Quantities

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I can...
estimate large and small quantities using a power of 10.

Explain It!

ACTIVITY

Keegan and Jeff did some research and found that there are approximately 7,492,000,000,000,000,000 grains of sand on Earth. Jeff says that it is about 7×10^{15} grains of sand. Keegan says that this is about 7×10^{18} grains of sand.

7,492,000,000,000,000,000

A. How might Jeff have determined his estimate? How might Keegan have determined his estimate?

B. Whose estimate, Jeff's or Keegan's, is more logical? Explain.

Focus on math practices

Be Precise Do you think the two estimates are close in value? Explain your reasoning.

Essential Question When would you use a power of 10 to estimate a quantity?

INTERACTIVE ANIMATION ANIMS

EXAMPLE 1 Estimate Very Large Quantities

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Janelle is comparing the estimated populations of Japan and China. The estimated population of Japan is 126,818,019. The estimated population of China is shown. How can Janelle compare the two populations more easily?

Use Structure You can estimate large quantities and write them in a format that is easier to compare.

STEP 1 Estimate each population by rounding to the greatest place value. Then write the number as a single digit times a power of 10.

Population of China	Population of Japan
1,402,941,487	126,818,019
rounds to 1,000,000,000	rounds to 100,000,000
1×10^9	1×10^8

Count the zeros to determine the power of 10.

STEP 2 Compare the estimated values.

$10^9 > 10^8$

$1 \times 10^9 > 1 \times 10^8$

Janelle can use estimates using powers of 10 to compare the populations more easily.

Try It!

Light travels 299,792,458 meters per second. Sound travels at 332 meters per second. About how much faster is the speed of light than the speed of sound?

299,792,458 rounded to the greatest place value is ☐.

There are ☐ zeros in the rounded number.

The estimated speed of light is ☐ × 10^☐ meters per second.

322 rounded to the greatest place value is ☐.

There are ☐ zeros in the rounded number.

The estimated speed of sound is ☐ × 10^☐.

The speed of light is 3 × 10^☐ − 3 × 10^☐, or 3 × 10^☐, meters per second faster.

Convince Me! Country A has a population of 1,238,682,005 and Country B has a population of 1,106,487,394. How would you compare these populations?

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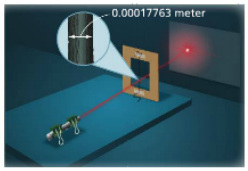
EXAMPLE 2 Estimate Very Small Quantities

Matthias used a laser to measure the average thickness of a human hair. A sheet of paper is about 0.0013 meter thick. How do the two thicknesses compare?



Write the estimated thickness of a human hair using a single digit and a power of 10.

Round 0.00017763 to 0.0002.

Write 0.0002 as 2×10^{-4}.

Write the estimated thickness of a sheet of paper using a single digit and a power of 10.

Round 0.0013 to 0.001.

Write 0.001 as 1×10^{-3}.

Compare the estimates.

$2 \times 10^{-4} < 1 \times 10^{-3}$

A human hair is thinner than a sheet of paper.

EXAMPLE 3 Find How Many Times as Much

How does the Gross Domestic Product (GDP) of Canada compare to that of the United States?

Gross Domestic Product	
Canada	$1,785,387,000,000,000
USA	$17,348,075,000,000,000

STEP 1 Write each GDP as a single digit times a power of 10.

Canada: $1{,}785{,}387{,}000{,}000{,}000 \approx 2{,}000{,}000{,}000{,}000{,}000 = 2 \times 10^{15}$

Count the zeros to determine the power of 10.

USA: $17{,}348{,}075{,}000{,}000{,}000 \approx 20{,}000{,}000{,}000{,}000{,}000 = 2 \times 10^{16}$

STEP 2 Compare the two estimates.

$(2 \times 10^{16}) > (2 \times 10^{15})$

The U.S. GDP is about 10 times greater than that of Canada.

Try It!

There are approximately 1,020,000,000 cars in the world. The number of cars in the United States is approximately 239,800,000.

Compare the number of cars in the world to that in the United States.

KEY CONCEPT

You can estimate a very large or very small number by rounding the number to its greatest place value, and then writing that number as a single digit times a power of 10.

Very Large Numbers

$3{,}564{,}879{,}000 \approx 4{,}000{,}000{,}000$

$\approx 4 \times 10^{9}$

The number is greater than 1, so the exponent is positive.

Count the number of zeros to determine the power of 10.

Very Small Numbers

$0.000000235 \approx 0.0000002$

$\approx 2 \times 10^{-7}$

The number is less than 1, so the exponent is negative.

Do You Understand?

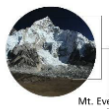
1. **Essential Question** When would you use powers of 10 to estimate a quantity?

2. **Construct Arguments** Kim writes an estimate for the number 0.00436 as 4×10^{3}. Explain why this cannot be correct.

3. **Be Precise** Raquel estimated 304,900,000,000 as 3×10^{8}. What error did she make?

Do You Know How?

4. Use a single digit times a power of 10 to estimate the height of Mt. Everest to the nearest ten thousand feet.



Mt. Everest is 29,035 feet tall.

4 digits

$\approx 30{,}000$ ft

3×10^{4}

5. A scientist records the mass of a proton as 0.000000000000000000000001672631 gram. Use a single digit times a power of 10 to estimate the mass.

$\approx 1.67 \ldots$

$\approx 2 \times 10^{-24}$

6. The tanks at the Georgia Aquarium hold approximately 8.4×10^{6} gallons of water. The tanks at the Audubon Aquarium of the Americas hold about 400,000 gallons of water. Use a single digit times a power of 10 to estimate how many times greater the amount of water is at the Georgia Aquarium.

GA 8.4×10^{6}

$\approx 8 \times 10^{6}$

AA $400{,}000$

4×10^{5}

8×10^{6} ×2 4×10^{5} 10^{1}

$\approx 2 \times 10^{1}$

Name: _____

Practice & Problem Solving

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Leveled Practice In 7–9, use powers of 10 to estimate quantities.

7. A city has a population of 2,549,786 people. Estimate this population to the nearest million. Express your answer as the product of a single digit and a power of 10.

Rounded to the nearest million, the population is about ☐.

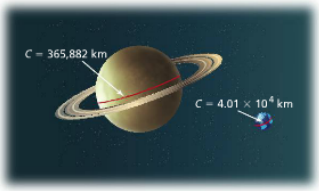
Written as the product of a single digit and a power of ten, this number is ☐ × 10☐.

8. Use a single digit times a power of 10 to estimate the number 0.00002468.

Rounded to the nearest hundred thousandth, the number is about ☐.

Written as a single digit times a power of ten, the estimate is ☐ × 10☐.

9. The approximate circumferences of Earth and Saturn are shown. How many times greater is the circumference of Saturn than the circumference of Earth?



The circumference of Saturn is ☐ × 10☐ km.

Saturn's circumference is about ☐ times greater than the circumference of Earth.

10. Estimate 0.037854921 to the nearest hundredth. Express your answer as a single digit times a power of ten.

11. Compare the numbers 6×10^{-6} and 2×10^{-8}.

a. Which number has the greater value?

b. Which number has the lesser value?

c. How many times greater is the greater number?

6×10^{-6} → ×3 → 2×10^{-8}

0.000006

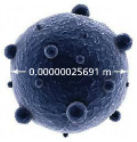
0.00000008

$3 \times 10^{2} = 300$ times

12. Taylor made $43,785 last year. Use a single digit times a power of ten to express this value rounded to the nearest ten thousand.

13. The length of plant cell A is 8×10^{-5} meter. The length of plant cell B is 0.000004 meter. How many times greater is plant cell A's length than plant cell B's length?

14. Critique Reasoning The diameter of one species of bacteria is shown. Bonnie approximates this measure as 3×10^{-11} meter. Is she correct? Explain.



15. The populations of Cities A and B are 2.6×10^5 and 1,560,000, respectively. The population of City C is twice the population of City B.

The population of City C is how many times the population of City A?

260000

City A : $2.6 \times 10^5 = 260{,}000$

×? → City B : 1,560,000

City C : 1,560,000 × 2 = 3,120,000

3.12×10^6

2.6×10^5

3,120,000 / 260,000

12 times

1.2×10^1

1.2×10

12 times

Assessment Practice

16. Earth is approximately 5×10^9 years old. For which of these ages could this be an approximation? Select all that apply.

- ☑ 4,762,100,000 years → $5 \times 10^{+9}$
- ☐ 4,849,000,000 years
- ☐ 48,000,000,000 years
- ☐ 4.45×10^9 years
- ☐ 4.849999999×10^9 years

17. PART A

Express 0.000000298 as a single digit times a power of ten rounded to the nearest ten millionth.

PART B

Explain how negative powers of 10 make small numbers to write and compare.