WORDS TO KNOW

scientific notation

coefficient

exponent

base

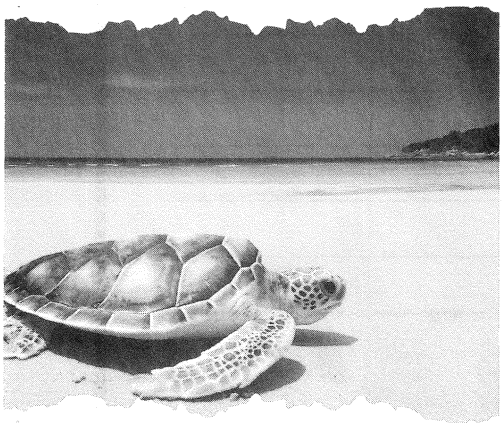
standard form

Lesson 6

PERFORM OPERATIONS WITH SCIENTIFIC NOTATION NY-8.EE.4

INTRODUCTION

Real-World Connection



A certain species of turtle walks at a rate of 0.0002 meter per second. Using scientific notation, the rate is 2×10^{-4} meter per second. There are 3,600, or 3.6×10^3, seconds in one hour. What is the rate at which the turtle walks in meters per hour? Let's practice the skills in the **Guided Instruction** and **Independent Practice** and see how quickly (or how slowly) the turtle walks at the end of the lesson!

What I Am Going to Learn

- How to multiply and divide with numbers in scientific notation

What I May Already Know

- I know how to write expressions using exponents.
- I know how to perform all four operations with multi-digit decimals.
- I know the properties of integer exponents.

Vocabulary in Action

Numbers written in **scientific notation** have the form $a \times 10^n$, and have two parts.

- The **coefficient**, a, is the first part where $1 \leq a \leq 10$.
- The power of 10 is the second part.

To multiply and divide numbers written in scientific notation:

- To multiply, first multiply the coefficients. Then multiply the powers of 10 by adding the **exponents**, or the powers. Keep the **base** as 10.
- To divide, first divide the coefficients. Then divide the powers of 10 by subtracting the exponents. Keep the base as 10.
- The result is sometimes written in **standard form**.

EXAMPLE

Multiply: 4.0×10^4 and 2.0×10^7

Step One Multiply the coefficients: $4 \times 2 = 8$

Step Two Multiply the powers of 10 by adding the exponents: $4 + 7 = 11$

Step Three Write the answer in correct scientific notation.

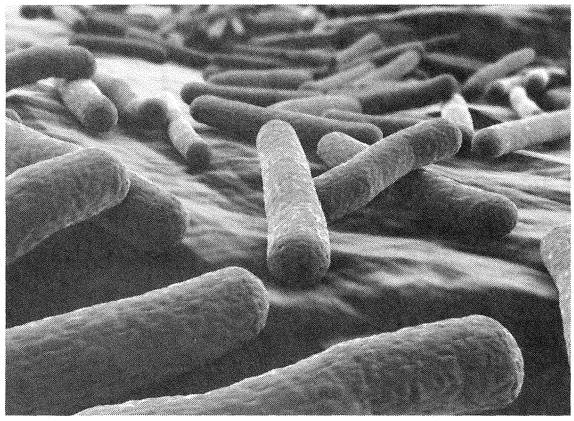
$4.0 \times 10^4 \times 2.0 \times 10^7 = 8.0 \times 10^{11}$

What happens if the product of the coefficients is less than 1, or greater than 10?

THINK ABOUT IT

How is the Commutative Property of Multiplication used in this problem?

EXAMPLE



An *E. coli* bacterium measures about 8.1×10^{-5} inches long. If 2.0×10^9 *E. coli* were placed end to end, how many inches would they measure?

Step One Multiply: 8.1×10^{-5} and 2.0×10^9

Multiply the coefficients: $8.1 \times 2.0 = 16.2$

Step Two Multiply the powers of 10 by adding the exponents: $-5 + 9 = 4$

Step Three Write the answer in correct scientific notation.

16.2×10^4, but $16.2 > 10$ and the value of a in scientific notation has be to between 1 and 10.

When this happens, adjust the coefficient and exponent accordingly:

Move the decimal point 1 to the left and add 1 to the exponent.

16.2 becomes 1.62.

10^4 becomes 10^5 to keep the product the same.

So, $8.1 \times 10^{-5} \times 2.0 \times 10^9 = 1.62 \times 10^5$ inches long.

TURN AND TALK

Why are the exponents added when the numbers are multiplied? Write out the multiplication of 10^3 and 10^4 to see. Why does adding still work if one or both exponents are negative?

Dividing numbers in scientific notation is a process similar to multiplying.

EXAMPLE

Divide 6.0×10^9 by 2.0×10^6.

Step One Divide the coefficients.

$6 \div 2 = 3$

Step Two Divide the powers of 10 by subtracting the exponents.

$9 - 6 = 3$

Step Three Write the answer in correct scientific notation.

$6.0 \times 10^9 \div 2.0 \times 10^6 = 3.0 \times 10^3$

GUIDED INSTRUCTION

1. The national debt of a country is 8.0×10^{12} dollars. If the country's financial goal is to pay back the debt 2.0×10^3 dollars at a time, how many payments will it take for the country to no longer be in debt? To find the answer, divide 8.0×10^{12} by 2.0×10^3.

Step One Divide the coefficients.

$8 \div 2 = 4$

Step Two Subtract the exponents.

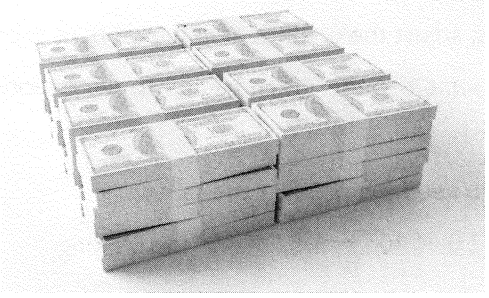
$12 - 3 = 9$

Step Three Write the answer in scientific notation. Check that the answer is in correct scientific notation.

$8.0 \times 10^{12} \div 2.0 \times 10^3 = 4.0 \times 10^9$

The coefficient is between 1 and 10, so it is in correct form.

It would take 4,000,000,000 payments.



2. Light travels approximately 1,080 million kilometers per hour. What is the speed of light in meters per hour? Express the answer in both scientific notation and standard form. There are 1000 meters in 1 kilometer.

Step One Convert the speed of light to scientific notation.

1,080 million or 1,080,000,000 or

1.08×10^9 kilometers per hour

TURN AND TALK

How are metric measurements and scientific notation connected?

Step Two Convert kilometers per hour to meters per hour.

1 kilometer per hour =

1,000 meters per hour, or 1×10^3 meters per hour

Step Three Multiply to find meters per hour.

$1.08 \times 10^9 \times 1.0 \times 10^3 =$ [ ] $\times 10^{12}$

Step Four Write the answer in standard form.

$1.08 \times 10^{12} = 1{,}080{,}000{,}000{,}000$ meters per hour

3. Simplify: $(7.0 \times 10^{-6})(4.0 \times 1^{-2})$

Step One Multiply the coefficients.

$7 \times 4 = 28$

Step Two Add the exponents.

$-6 + (-2) =$ [ ]

Step Three Check that the answer is in correct scientific notation.

$(7.0 \times 10^{-6})(4.0 \times 10^{-2}) =$ [ ] $\times 10^{-8}$

The answer is not in correct scientific notation because the coefficient is not a number between 1 and 10.

Step Four Convert to correct scientific notation.

$28.0 \times 10^{-8} = 2.8 \times$ [ ]

TIPS AND HINTS

Are you dividing the diameter of a grain of sand by the total distance or the total distance by the diameter of the grain of sand?

4. The diameter of a grain of sand is about 0.0024 inch. About how many grains of sand would be needed to cover a distance of 1×10^6 inches?

Ⓐ 4.2×10^8

Ⓑ 4.2×10^9

Ⓒ 2.4×10^3

Ⓓ 2,400

TIPS AND HINTS

Write each number in correct scientific notation before finding the product.

5. Use scientific notation to simplify $0.00004 \times 200{,}000$. Explain how you used scientific notation to get your answer.

Rewrite 0.00004 as 4.0×10^{-5} and 200,000 as 2.0×10^5. Next, multiply the coefficients: [ ] $\times 2 = 8$. Add the exponents: $-5 +$ [ ] $= 0$. The answer in scientific notation is $8.0 \times 10^{[\ ]}$.

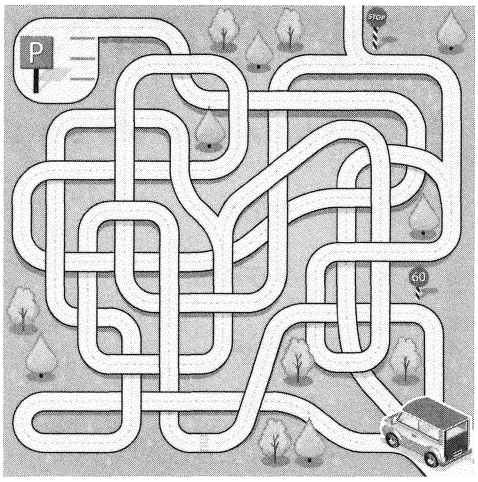
$10^0 = 1$, so the answer is 8.

Learning Together

Work with a partner to create a maze with multiple 2-option junctures. At each juncture, place two multiplication or division problems with scientific notation.

As you place the problems, make sure one of the two problems at each juncture is greater than the other so that, by always choosing the greater option, a person could successfully traverse the maze. Have the wrong answers either lead back to the beginning or into a loop that comes back to the juncture.

Trade mazes with another team and see how long it takes each team to get through the maze to THE END.



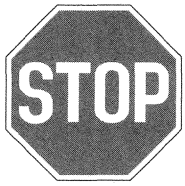
How Am I Doing?

What questions do you have?

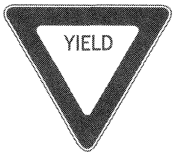
How are the steps to multiplying numbers in scientific notation different from the steps to dividing numbers in scientific notation?

What are examples of numbers in powers of ten that you see in daily life or in measurement?

Circle the sign that shows how you are doing with the skill.



I am stuck.



I almost have it.

I understand the skill.

INDEPENDENT PRACTICE 1

1 What is the value of 1.9×10^{-3}?

A −1,900

B −0.0019

C 0.0019

D 1,900

SKETCH IT

Write 1.9. Then use curved lines to visually mark the decimal movement.

2 The United States uses 4×10^9 megawatt hours of electricity in a year. Mexico uses 2×10^8 megawatt hours in a year. How many times more megawatt hours does the United States use than Mexico in a year?

A 2

B 8

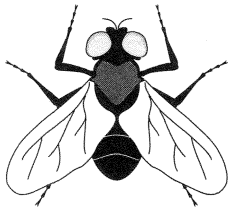
C 10

D 20

TIPS AND HINTS

Remember that $10^1 = 10$.

3 A fly's wings beat approximately 1.2×10^4 times per minute.



About how many times do the fly's wings beat in 1 second?

A 200

B 1,200

C 2,000

D 12,000

TIPS AND HINTS

Why wouldn't it work well to just watch a fly and count the number of wing beats, instead of doing the math to complete this question?

4 New York state covers approximately 55,000 square miles. In 2004, the estimated population of New York state was 19,000,000. In 2005, the estimated population of New York state was 21,000,000.

Express the number of square miles, the population in 2004, and the population in 2005 in scientific notation.

THINK ABOUT IT

Why is it important to always start converting to scientific notation by writing a number between 1 and 10?

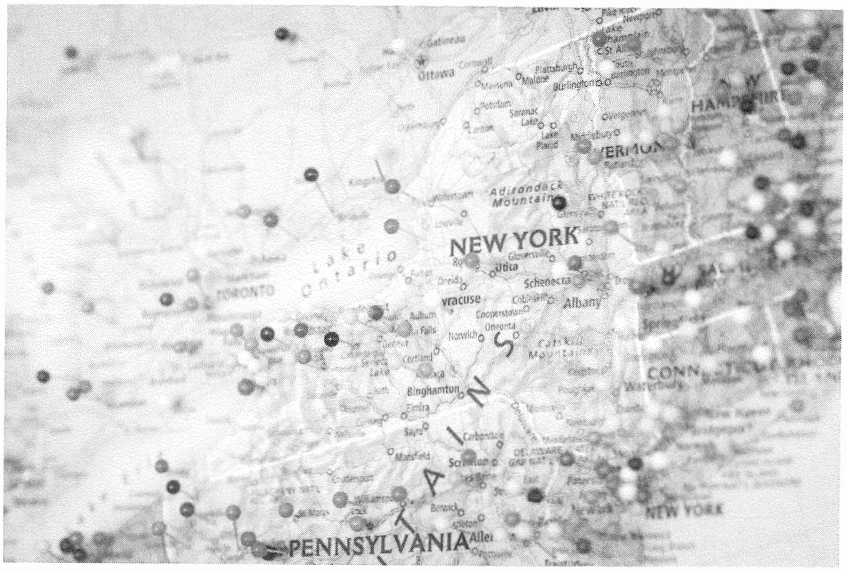
Answer Square miles: _____ square miles

Population in 2004: _____ people

Population in 2005: _____ people

Estimate the number of people per square mile in New York State in 2004. Round your answer to the nearest whole number.

Explain your answer.



INDEPENDENT PRACTICE 2

1 Simplify: $\frac{8 \times 10^9}{2 \times 10^{-1}}$

A 4.0×10^{-8}

B 4.0×10^{8}

C 4.0×10^{9}

D 4.0×10^{10}

2 Multiply $(8 \times 10^3) \times (2 \times 10^6)$. What is the answer in scientific notation?

A 1.6×10^{10}

B 1.6×10^{18}

C 16×10^{3}

D 16×10^{10}

3 Which product has a value greater than 10?

A $(1 \times 10^3) \times (3 \times 10^{-4})$

B $(2 \times 10^{-3}) \times (2 \times 10^4)$

C $(4 \times 10^{-3}) \times (1 \times 10^3)$

D $(3 \times 10^{-4}) \times (2 \times 10^4)$

4 Which value completes the statement?

$$3 \times 10^{-2} \times \square = 1.2 \times 10^7$$

A 4×10^{6}

B 4×10^{5}

C 4×10^{8}

D 4×10^{9}

5 There are about 1.2×10^8 households in the United States. The mean income per household is about $\$7.0 \times 10^4$. In scientific notation, what is the total household income in the United States?

A $\$8.4 \times 10^4$

B $\$84 \times 10^4$

C $\$8.4 \times 10^{12}$

D $\$84 \times 10^{12}$

6 An Internet search engine receives 1.6×10^{12} search queries per year. There are approximately 3.2×10^7 seconds in a year. On average, how many search queries are there per second?

A 4.8×10^{19}

B 5.0×10^4

C 5.0×10^{19}

D 4.8×10^4

7 Which product is greater than 1×10^3?

A $(2 \times 10^{-7}) \times (2 \times 10^{-2})$

B $(2 \times 10^3) \times (2 \times 10^{-3})$

C $(2 \times 10^{-4}) \times (2 \times 10^{-2})$

D $(2 \times 10^2) \times (2 \times 10^2)$

8 The population of the United States is approximately 3.2×10^8. The total area of the United States is approximately 4.0×10^6 square miles. On average, how many people are there per square mile? Write your answer in scientific notation and in standard form.

Answer _____ people per square mile (scientific notation)

_____ people per square mile (standard form)

Explain your answer.

9 Determine which of these is larger without actually performing the calculation.

$$(8 \times 10^7) \times (3 \times 10^{-3}) \text{ or } \frac{8 \times 10^7}{3 \times 10^{-3}}$$

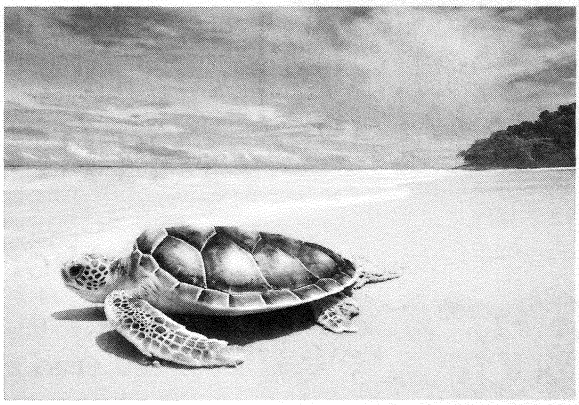
Explain your answer.

EXIT TICKET

NY-8.EE.4

Now that you have mastered multiplying and dividing with scientific notation, let's solve the problem in the **Real-World Connection**.

A certain species of turtle walks at a rate of 0.0002 meter per second. Using scientific notation, the rate is 2×10^{-4} meter per second. There are 3,600, or 3.6×10^{3}, seconds in one hour. What is the rate at which the turtle walks in meters per hour? How far can the turtle walk in one hour? Write the answer in scientific notation and in standard form.



How far can the turtle walk in three hours?