Scientific Notation

Use What You Know

You've learned about place value and investigated multiplying and dividing by powers of 10. Now, take a look at this problem.

The planet Venus is more than 60,000,000 miles from the Sun. Write this number as the product of two factors:

(a number greater than or equal to 1 but less than 10) × (a power of 10)

Use the math you already know to solve the problem.

a. Write 60,000,000 in words. _____

b. Fill in the missing factor: 60,000,000 = 6 • _____

c. Write the second factor in the equation as a product of 10s.

_____

d. Write the second factor as a power of 10. Explain your reasoning.

_____

_____

e. Explain how you could write 60,000,000 as the product of a number greater than or equal to 1 that is multiplied by a power of 10. _____

_____

_____

_____

Find Out More

Scientists often work with very large numbers, such as the distance from Venus to the Sun or the number of cells in a human body. Writing and calculating with very large numbers can be tedious and inconvenient.

When you wrote 60,000,000 as 6×10^7, you used **scientific notation**. Scientific notation uses exponents to make it easier to work with very large or very small numbers. To write a number using scientific notation, write it as a product of two factors:

a number that is greater than or equal to 1 but less than 10 — 6×10^7 — a power of 10

To write the number 1,850,000 in scientific notation,

$1{,}850{,}000 = 1.850000.$ Move the decimal point to get a number that is at least 1, but less than 10.

$= 1.85 \times 10^6$ The power of 10 is equal to **the number of place values that the decimal point moved**.

The power doesn't tell you the number of zeros in the standard form of the number. Rather, it tells you the greatest place value of the number.

To write the number 3.54×10^5 in standard form, we move each digit in 3.54 up 5 place values by **moving the decimal point 5 places to the right**, because we are multiplying by 10^5.

$3.54 \times 10^5 = 3.54000 = 354{,}000$

To translate between scientific notation and standard notation, change the place values of the digits by moving the decimal point according to the power of 10.

Reflect

1 Write 6.85×10^8 in standard form. Show your work.

Learn About Writing Numbers in Scientific Notation

Read the problem below. Then explore how to write very small numbers using scientific notation.

Seven nanoseconds is equivalent to 7 one-billionths of a second, or 0.000000007 second. Write 0.000000007 in scientific notation.

Picture It Look at the patterns in the chart below.

100	$10 \cdot 10$	10^2
10	10	10^1
1	1	10^0
0.1	$\frac{1}{10} = \frac{1}{10^1}$	10^{-1}
0.01	$\frac{1}{10 \cdot 10} = \frac{1}{10^2}$	10^{-2}
0.001	$\frac{1}{10 \cdot 10 \cdot 10} = \frac{1}{10^3}$	10^{-3}
0.0001	$\frac{1}{10 \cdot 10 \cdot 10 \cdot 10} = \frac{1}{10^4}$	10^{-4}

Model It You can write the decimal as a fraction.

$$0.000000007 = \frac{7}{1{,}000{,}000{,}000}$$

$$= 7 \cdot \frac{1}{1{,}000{,}000{,}000}$$

Solve It You can write the number as the product of a number that is greater than or equal to 1 but less than 10 and a power of 10.

0.000000007	Move the decimal point **9 places to the right** to get a number between 1 and 10.
7×10^{-9}	Because the number is less than 1, the exponent is negative. The absolute value of the exponent is equal to the number of places the decimal point moved to get the number between 1 and 10.

Connect It Now look at different ways to solve the problem.

2 Write 1,000,000,000 as a product of 10s. _____

3 Write 1,000,000,000 as a power of 10. _____

4 Look at the table on the previous page. Write $\frac{1}{1{,}000{,}000{,}000}$ as 10 to a power to complete the equation: $7 \cdot \frac{1}{1{,}000{,}000{,}000} =$ _____ $\times$ _____

5 Look at *Solve It*. When you have to move the decimal point to the right to express a number in scientific notation, will the power of 10 be positive or negative? _____

6 When a number is written in scientific notation, a _____ exponent means the number is at least 1 and a _____ exponent means the number is between 0 and 1.

7 Is 2.14×10^{-5} at least 1 or between 0 and 1? Explain.

_____

8 Write $2.14 \cdot 10^{-5}$ in standard form.

$2.14 \times 10^{-5} = \frac{214}{100} \times \frac{1}{10^5}$

$=$ _____

$=$ _____

9 Explain how to write $2.14 \cdot 10^{-5}$ in standard form by moving the decimal point.

_____

_____

Try It Use what you just learned to solve these problems. Show your work on a separate sheet of paper.

10 Write 63,120,000 in scientific notation. _____

11 Write 9.054×10^{-6} in standard form. _____

Learn About Comparing Numbers in Scientific Notation

Read the problem below. Then explore how to compare numbers written in scientific notation.

Earth is about 1.5×10^8 kilometers from the Sun, while the planet Neptune is almost 4.5×10^9 kilometers from the Sun. The distance from Neptune to the Sun is about how many times the distance from Earth to the Sun?

Model It

You can write the distances of the planets from the Sun in standard form and compare them.

1.5×10^8 kilometers $=$ 150,000,000 kilometers

4.5×10^9 kilometers $=$ 4,500,000,000 kilometers

To find how many times as great 4,500,000,000 is than 150,000,000, divide.

4,500,000,000 ÷ 150,000,000

Model It

You can compare the distances of the planets from the Sun using scientific notation.

To compare 1.5×10^8 and 4.5×10^9:

First, compare 1.5 and 4.5.

4.5 is how many times as great as 1.5?

Then, compare 10^8 and 10^9.

10^9 is how many times as great as 10^8?

Connect It **Now you will solve the problem using standard form and scientific notation.**

12 Look at the first *Model It* on the previous page. 4,500,000,000 is how many times the value of 150,000,000?

13 Look at the second Model It. 4.5 is how many times the value of 1.5? Explain your reasoning.

14 10^9 is how many times the value of 10^8? Explain your reasoning.

15 Look at your answers to problems 13 and 14. 4.5×10^9 is how many times the value of 1.5×10^8? Give your answer in both scientific notation and standard form.

16 Which method of comparing the numbers would you use? Explain.

Try It **Use what you just learned to solve these problems. Show your work on a separate sheet of paper.**

17 6×10^{-5} is how many times the value of 3×10^{-8}?

18 Star A is about 3.4×10^{18} miles from Earth. Star B is 6.8×10^{16} miles from Earth. Star A is how many times as far from Earth as Star B?

Practice Writing and Comparing Numbers in Scientific Notation

Study the example below. Then solve problems 19–21.

Example

Write 0.0000408306 in scientific notation.

Look at how you could solve this problem.

In scientific notation, the solution will look like $n \cdot 10^a$.
n must be greater than or equal to 1 and less than 10.
a must be an integer.

To write 0.0000408306 in scientific notation, first move the decimal point 5 places to the right. Then multiply that number by a power of 10. The exponent in that power of 10 will be -5, which is found by counting the number of places the decimal is moved to the right.

Solution $0.0000408306 = 4.08306 \times 10^{-5}$

The student moved the decimal point the number of places necessary to get a number greater than or equal to 1 and less than 10.

Pair/Share
What is another method you could use to write the number in scientific notation?

19 Earth is about 5,974,000,000,000,000,000,000,000 kg. Write this number in scientific notation.

Show your work.

Solution _____

Do you move the decimal point to the right or to the left to write the number in scientific notation?

Pair/Share
Explain why the procedure used to write a number in scientific notation works.

20 Use the information in the table to solve the problem.

Orbiting Body	Approximate Distance from the Sun (in miles)
Mercury	36,300,000
Mars	142,000,000
Neptune	2,800,000,000
Pluto	3,670,000,000

Will the exponent be positive or negative?

Show your work.

Write each distance in scientific notation.

Mercury _____

Mars _____

Neptune _____

Pluto _____

Neptune is about how many times as far from the Sun as Mars is from the Sun?

Solution: _____

Pair/Share
How does writing numbers in scientific notation make numbers easier to work with?

21 Which is equivalent to 8.03×10^{-8}?

A $-803{,}000{,}000$

B -0.0000000803

C 0.0000000803

D $803{,}000{,}000$

Will the solution be a negative number or positive number?

Eva chose **D** as the correct answer. How did she get that answer?

Pair/Share
Talk about the problem and then write your answer together.

Practice Writing and Comparing Numbers in Scientific Notation

Solve the problems.

1 Which of the following expressions is equivalent to 5,710,900?

A 5.7109×10^{-6}

B 57109×10^{2}

C 5.7109×10^{3}

D 5.7109×10^{6}

2 The average distance from Pluto to the Sun is about 6×10^{9} kilometers. The average distance from Mars to the Sun is 2×10^{8} kilometers. The average distance from Pluto to the Sun is about how many times as great as the average distance from Mars to the Sun?

_____ times

3 Last year a business earned 4.1×10^{6} dollars in income. This year the business earned 2.05×10^{8} dollars in income. Which ***best*** describes how this year's earnings compare to last year's earnings?

A This year the business earned about 0.5 times as much as it did last year.

B This year the business earned about 2 times as much as it did last year.

C This year the business earned about 50 times as much as it did last year.

D This year the business earned about 100 times as much as it did last year.

4 Write the following numbers in order from ***least*** to ***greatest***.

5×10^{-6} $\quad -9 \times 10^{-3}$

-0.0000002 $\quad 0.00007$

Least ⟶ Greatest

5 Cara was using her calculator to solve a problem. The answer that displayed was 1.6E+12. She knows that she entered all of the numbers correctly. Why did the calculator give the answer it did? What is the answer to Cara's problem?

6 The length of a city block running north to south in New York City is about 5×10^{-2} miles. The distance from New York City to Mumbai, India, is about 7.5×10^{3} miles. The distance from New York City to Mumbai is about how many times the length of a New York City north-south block?

Show your work.

Answer _____

Self Check **Go back and see what you can check off on the Self Check on page 1.**