Lesson 4-4

Scientific Notation

Interactive Study Guide

See pages 79–80 for:
- Getting Started
- Real-World Link
- Notes

Essential Question

Why is it useful to write numbers in different ways?

Common Core State Standards

Content Standards
8.EE.1, 8.EE.3, 8.EE.4

Mathematical Practices
1, 3, 4, 7

Vocabulary

standard form

scientific notation

What You'll Learn

- Express numbers in standard form and in scientific notation.
- Compare and order numbers written in scientific notation.

Real-World Link

Space Earth is the third planet from the Sun in our solar system. Because Earth's rotation about the Sun is not circular, the maximum distance between Earth and the Sun is about 95 million miles and the minimum distance is about 91 million miles.

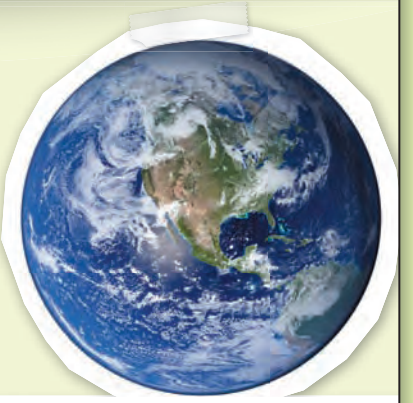

Image by Reto Stockli, NASA/Goddard Space Flight Center. Enhancements by Robert Simmon.

Key Concept **Scientific Notation**

Words	A number is expressed in scientific notation when it is written as the product of a factor and a power of 10. The factor must be greater than or equal to 1 and less than 10.
Symbols	$a \times 10^n$, where $1 \leq a < 10$ and n is an integer.
Examples	$3{,}500{,}000 = 3.5 \times 10^6$ $\quad$ $0.00004 = 4 \times 10^{-5}$

Numbers that do not contain exponents are written in **standard form**. However, when you deal with very large numbers like 12,760,000 or very small numbers like 0.00001276, it can be difficult to keep track of the place value. A number that is expressed as a product of a factor and a power of 10 is written in **scientific notation**.

When a number is expressed in scientific notation the exponent tells you how many places to move the decimal point.

Example 1

Tutor

Express each number in standard form.

a. 2×10^3

$2 \times 10^3 = 2000$ Move the decimal point 3 places to the right.

b. 6.8×10^5

$6.8 \times 10^5 = 680{,}000$ Move the decimal point 5 places to the right.

c. 3.25×10^{-4}

$3.25 \times 10^{-4} = 0.000325$ Move the decimal point 4 places to the left.

Got It? Do these problems to find out.

1a. 4×10^2 **400** **1b.** 5.94×10^7 **59,400,000** **1c.** 1.3×10^{-3} **0.0013**

2 Teach the Concept

Objectives write, compare, and order numbers in scientific notation

Building on the Essential Question

At the end of the lesson, students should be able to answer "Why is the conclusion that 7.8×10^3 is greater than 6.5×10^2 because $7.8 > 6.5$ incorrect?"

Example 1

What's the Math? write numbers in standard form

- *Given a number expressed in scientific notation, what does a positive exponent tell you?* **It tells you how many places to move the decimal point to the right when you write the number in standard form.**
- *Given a number expressed in scientific notation, what does a negative exponent tell you?* **It tells you how many places to move the decimal point to the left when you write the number in standard form.**

Need Another Example?

Express each number in standard form.

a. 3×10^5 **300,000**

b. 4.395×10^4 **43,950**

c. 6.79×10^{-6} **0.00000679**

Example 2

What's the Math? write numbers in scientific notation

- *When you express a number in scientific notation, how do you determine the value of the exponent?* **Count the number of places to the right of the leftmost digit if the number is greater than 1, and from the right of the decimal point to the first nonzero digit, if the number is less than 1.**

Need Another Example?

Express each number in scientific notation.

a. 800,000 **8×10^5** **b.** 0.0119 **1.19×10^{-2}**

Example 3

What's the Math? estimate numbers in scientific notation

- *What is the first step in estimating with scientific notation?* **Round the number in standard form to the greatest place value.**

Need Another Example?

The population of Montana is 998,199. Write an estimation in scientific notation for the population.
Sample answer: 1×10^6

Example 4

What's the Math? choose units of appropriate size

- *If you walked 1 mile, would you say that you walked for about 20 minutes or about 1200 seconds?* **20 min**

Need Another Example?

If you could ride your bike 200 meters per second, it would take about 1.92×10^6 seconds to ride to the moon. Is it more appropriate to report this time as about 1.92×10^6 seconds or about 22.2 days?
22.2 days; The number of meters to the moon is very large, so the larger unit is more appropriate.

When expressing a number in scientific notation, the sign of the exponent can be determined by evaluating the number in standard form. If a number in standard form is greater than or equal to 1, then the exponent is *positive*. If a number is between 0 and 1, then the exponent is *negative*.

Scientific Notation
When numbers are expressed in scientific notation, no more than one digit is to the left of the decimal point.

Example 2

Tutor

Express each number in scientific notation.

a. 4,000,000
$4{,}000{,}000 = 4 \times 10^6$ — The decimal point moves 6 places. The exponent is positive.

b. 0.072
$0.072 = 7.2 \times 10^{-2}$ — The decimal point moves 2 places. The exponent is negative.

Got It? Do these problems to find out.

2a. 900 **9×10^2** **2b.** 18,900 **1.89×10^4** **2c.** 0.000064 **6.4×10^{-5}**

One way to estimate a very large or a very small number is to express it in the form of a single digit times an integer power of 10. For example, the population of the United States in 2010 was 308,745,538. The number 3×10^8 is an estimate of that number.

Example 3

Tutor

The population of Kansas is 2,853,118 people. Write an estimation in scientific notation for the population.

$2{,}853{,}118 \approx 3{,}000{,}000$ — Estimate.
$3{,}000{,}000 = 3 \times 10^6$ — Write in scientific notation.

The population of Kansas is about 3×10^6 people.

Got It? Do these problems to find out.

Estimate each value using scientific notation. **3a–3c. Sample answers are given.**

3a. 3,612,500 cm **4×10^6 cm** **3b.** 0.000000251 ft **3×10^{-7} ft** **3c.** 4.215×10^{-3} kg **4×10^{-3} kg**

Example 4

Real World Tutor

STEM **The space shuttle traveled at about 8 kilometers per second. At this rate, the shuttle would take about 4.5×10^4 seconds to fly to the moon. Is it more appropriate for a newspaper to report this time as about 4.5×10^4 seconds or about 12.5 hours? Explain your reasoning.**

The measure 12.5 hours is more appropriate. The number 4.5×10^4 seconds is very large, so choosing the larger unit of measure is more meaningful.

Got It? Do this problem to find out.

4. A dime is about 5.875×10^{-3} foot in diameter. Is it more appropriate to report that the diameter of a dime is 5.875×10^{-3} foot or 7.05×10^{-1} inch? Explain your reasoning.

4. 7.05×10^{-1} in.; A dime's diameter is not very large, so choosing the smaller unit of measure is more meaningful.

Compare and Order Numbers

To compare and order numbers in scientific notation, first compare the exponents. With positive numbers, the number with a greater exponent is greater. If the exponents are the same, compare the factors.

Power of 10
When writing a number in scientific notation, the power of 10 is determined by the direction and number of places you move the decimal point.

Example 5

STEM **The table shows different geologic time periods. Order the time periods from oldest to youngest.**

Geologic Time Periods	
Period	Number of Years Ago
Jurassic	2.08×10^8
Silurian	4.38×10^8
Tertiary	6.64×10^7
Triassic	2.45×10^8

Step 1 Order the numbers according to their exponents.

The Tertiary period has an exponent of 7. So, it is the youngest period.

Step 2 Order the numbers with the same exponent by comparing the factors.

4.38 (Silurian) $>$ 2.45 (Triassic) $>$ 2.08 (Jurassic)

So, $4.38 \times 10^8 > 2.45 \times 10^8 > 2.08 \times 10^8$.

The time periods ordered from oldest to youngest are Silurian, Triassic, Jurassic, and Tertiary.

Got It? **Do this problem to find out.**

5. **STEM** Approximately 1.372×10^7 square kilometers of Antarctica and about 1.834×10^6 square kilometers of Greenland are covered by an ice cap. Which land mass has a greater area covered by ice? **Antarctica**

10. 1.4×10^2 h; The number is very large so choosing a larger unit of measure is more meaningful.

Guided Practice

Express each number in standard form. (Example 1)

1. 4.16×10^3 **4160** **2.** 3.2×10^{-2} **0.032** **3.** 1.075×10^5 **107,500**

Express each number in scientific notation. (Example 2)

4. 1,600,000 **1.6×10^6** **5.** 135,000 **1.35×10^5** **6.** 0.008 **8×10^{-3}**

Estimate each value using scientific notation. (Example 3) **7–9. Sample answers are given.**

7. 0.000007109 kg **7×10^{-6} kg** **8.** 3.7085×10^{14} mL **4×10^{14} mL** **9.** 18,900,435 cm **2×10^7 cm**

10. If you could walk at the rate of about 1 mile every 20 minutes without stopping, it would take about 1.4×10^2 hours to walk from Columbus, Ohio, to Washington, D.C. Is it more appropriate to report the time as 1.4×10^2 hours or 8.4×10^3 minutes? Explain. (Example 4)

11. Order 3.4×10^2, 3.5×10^2, 3.7×10^{-2}, and 400 from least to greatest. (Example 5)

11. 3.7×10^{-2}, 3.4×10^2, 3.5×10^2, 400

Example 5

What's the Math? order numbers in scientific notation

- *When ordering numbers written in scientific notation, what must you compare first?* **their exponents**

Need Another Example?

The diameters of Neptune, Saturn, and Uranus are 4.9×10^4 kilometers, 1.2×10^5 kilometers, and 5.1×10^4 kilometers, respectively. Order the planets from greatest to least diameter. **Saturn, Uranus, Neptune**

Formative Assessment

Guided Practice Use these exercises to assess students' understanding of the concept of the lesson. If they need more help, use the Personal Tutors available online.

TICKET Out the Door

Tell students to write how they think what they learned about negative exponents helped them with today's lesson on scientific notation. Ask them to include reasons negative exponents and scientific notation might be useful. They can illustrate with examples. **See students' work.**