

Scientific Notation

Complete Unit

(Refined Edition)

Operations, Real-World & Science Connections
Grade 8 Mathematics

Common Core State Standards

8.EE.A.3: Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other.

8.EE.A.4: Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities.

What's Inside This Unit:

- 5 Topic Progressions with Visual Guided Notes
- 40-Problem Conversion Drill (with detailed solutions)
- 30-Problem Operations Drill (with detailed solutions)
- 20-Problem Comparison & Estimation Activity (with detailed solutions)
- 20 Real-World STEM Context Problems (with detailed solutions)
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- **"Watch Out!" common-mistake callouts on every topic**

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Topic 1: Introduction to Scientific Notation

PREVIEW

CCSS: 8.EE.A.3 — Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities.

What Is Scientific Notation?

Scientific notation is a compact way to write very large or very small numbers. Instead of writing out long strings of zeros, we express a number as the product of two parts: a **significand** (also called the coefficient) and a **power of 10**.

The general form is:

$$a \times 10^n$$

where $1 \leq |a| < 10$ (the significand is at least 1 and less than 10) and n is an integer (the exponent can be positive, negative, or zero).

Significand ($1 \leq a < 10$)	$\times$	Power of 10 10^n
3.4	$\times$	10^6

Key Idea: The significand must be at least 1 and less than 10. This means exactly one non-zero digit appears before the decimal point. The exponent tells us how many places (and in which direction) the decimal point moved.

Why Use Scientific Notation?

Scientists and engineers work with extremely large and extremely small numbers every day. Consider these examples:

Quantity	Standard Form	Scientific Notation
Distance from Earth to Sun	93,000,000 mi	9.3×10^7 mi
Mass of a hydrogen atom	0.000000000000000000000000 1674 g	1.674×10^{-24} g
Speed of light	299,792,458 m/s	2.99792458×10^8 m/s
Diameter of a red blood cell	0.000008 m	8×10^{-6} m

Converting Large Numbers to Scientific Notation

When a number is **10 or greater**, we convert to scientific notation by moving the decimal until only one non-zero digit remains to its left. The number of places moved becomes exponent.

PREVIEW

EXAMPLE 1: Large Number to Scientific Notation

CCSS: 8.EE.A.3

Convert 45,300,000 to scientific notation.

Standard Form	move 7 place(s) LEFT	Scientific Notation
45,300,000	←←←←←←←	4.53×10^7

Identify: The number 45,300,000 is greater than 10, so we will move the decimal LEFT.

Apply: Place the decimal at the end of the number: 45,300,000. Move it left until only the 4 remains to its left. Count the moves: 7 places.

Solve: Significand = 4.53 (the digits remaining after the move). Exponent = +7 (positive because we moved left for a large number).

Verify: $4.53 \times 10^7 = 4.53 \times 10,000,000 = 45,300,000$. ✓

Result: 4.53×10^7

EXAMPLE 2: Large Number to Scientific Notation

CCSS: 8.EE.A.3

Convert 8,904,000,000 to scientific notation.

Standard Form	move 9 place(s) LEFT	Scientific Notation
8,904,000,000	←←←←←←←←←	8.904×10^9

Identify: The number is greater than 10; move the decimal LEFT.

Apply: Decimal starts at the end: 8,904,000,000. Move left until only the 8 remains. Count: 9 places.

Solve: Significand = 8.904. Exponent = +9.

Verify: $8.904 \times 10^9 = 8,904,000,000$. ✓

Result: 8.904×10^9

EXAMPLE 4: Multiplication Requiring Adjustment

CCSS: 8.EE.A.4

PREVIEW

Calculate: $(6 \times 10^4) \times (4.5 \times 10^{-2})$. Write the answer in scientific notation.

Visual Step Flow

$$(6 \times 10^4) \times (4.5 \times 10^{-2})$$

$$(6 \times 4.5) \times (10^4 \times 10^{-2}) \quad [\text{group}]$$

$$27 \times 10^2 \quad [6 \times 4.5 = 27, 4 + (-2) = 2]$$

$$2.7 \times 10^3 \quad [\text{ADJUSTMENT: move left, +1 to exp}]$$

Identify: Multiplication problem. We will group significands together and powers of 10 together.

Apply: Rewrite as $(6 \times 4.5) \times (10^4 \times 10^{-2})$. Multiply significands: $6 \times 4.5 = 27$. Add exponents: $4 + (-2) = 2$.

Solve: Combine: 27×10^2 . But 27 is not in $[1, 10)$, so adjust: move decimal 1 place left to get 2.7, add 1 to exponent: $2 + 1 = 3$.

Verify: $2.7 \times 10^3 = 2,700$. Check: $(6 \times 10,000) \times (4.5 \times 0.01) = 60,000 \times 0.045 = 2,700$. ✓

$$\text{Result: } 2.7 \times 10^3$$

Conversion Drill (40 Problems)

PREVIEW

CCSS: 8.EE.A.3 — Convert between standard form and scientific notation.

Instructions: Convert each number. Problems 1–20: standard form → scientific notation. Problems 21–40: scientific notation → standard form. Show your work using the Identify → Apply → Solve → Verify framework.

- | | | | |
|------------------------|--------------------------|---------------------------|----------------------------|
| 1. 34,000 | 2. 0.00056 | 3. 9,200,000 | 4. 0.0000081 |
| 5. 780,000 | 6. 0.045 | 7. 12,500,000,000 | 8. 0.00000033 |
| 9. 6,000,000 | 10. 0.00000000914 | 11. 450,000,000 | 12. 0.000702 |
| 13. 8,910,000 | 14. 0.0000059 | 15. 23,000,000 | 16. 0.000000066 |
| 17. 540,000 | 18. 0.000038 | 19. 1,200,000,000,000 | 20. 0.00000000125 |
| 21. 4.1×10^3 | 22. 7.5×10^{-3} | 23. 6.2×10^5 | 24. 3.8×10^{-5} |
| 25. 1.05×10^6 | 26. 9.9×10^{-4} | 27. 8×10^8 | 28. 5.01×10^{-7} |
| 29. 2.34×10^4 | 30. 1.2×10^{-6} | 31. 7.5×10^9 | 32. 6.45×10^{-2} |
| 33. 3.1×10^7 | 34. 8.8×10^{-8} | 35. 5×10^{11} | 36. 2.08×10^{-3} |
| 37. 9.1×10^5 | 38. 4.7×10^{-9} | 39. 1.25×10^{10} | 40. 7.007×10^{-4} |

Real-World STEM Context Problems (20 Problems)

PREVIEW

CCSS: 8.EE.A.4 — Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities.

Solve the following multi-step STEM problems. Express answers in scientific notation with appropriate units.

1. **Astronomy:** The distance to a star is 4.2×10^{16} m. Light travels at 3×10^8 m/s. How many seconds does it take light to reach the star?
2. **Biology:** A lab has 5×10^6 cells. If each mL contains 2.5×10^3 cells, what is the total volume in mL?
3. **Chemistry:** A sample contains 6×10^{23} atoms. If one atom has a mass of 2×10^{-23} g, what is the total mass of the sample?
4. **Geology:** Earth's mass is 5.4×10^{24} kg and its volume is 1.08×10^{12} km³. What is Earth's average density in kg/km³?
5. **Technology:** A processor performs 2.5×10^9 calculations per second. How many calculations in 8×10^3 seconds?
6. **Astronomy:** The Sun's mass is 1.8×10^{30} kg. Earth's mass is 6×10^{24} kg. How many times more massive is the Sun?
7. **Biology:** A single bacterium has a mass of 3×10^{-15} g. What is the mass of 1,000 bacteria?
8. **Geology:** Earthquake A releases 4×10^8 joules. Earthquake B releases 2×10^{12} joules. How many times more energy did B release?
9. **Technology:** A flash drive holds 8×10^9 bytes. If a file is 4×10^6 bytes, how many files can fit on the drive?
10. **Chemistry:** A solution has a concentration of 5×10^{-4} mol/L. How many moles are in 2×10^3 L of solution?
11. **Astronomy:** A galaxy is 9.5×10^{20} m wide and 1×10^{18} m thick. The width is how many times the thickness?
12. **Biology:** Human DNA in one cell is 2×10^9 base pairs long. How many base pairs in 3×10^5 cells?
13. **Geology:** A tectonic plate moves 5×10^{-2} m per year. How far does it move in 4×10^6 years?
14. **Technology:** A network transfers 1.5×10^6 bits per second. How long to transfer 3×10^8 bits?
15. **Astronomy:** A neutron star has a mass of 2×10^{30} kg and a volume of 4×10^{12} m³. What is its density?
16. **Biology:** The human body has $\sim 3.75 \times 10^{13}$ cells. About 2.5×10^{13} are red blood cells. What fraction of total cells are red blood cells?
17. **Geology:** The ocean's mass is 1.4×10^{21} kg. A drop of water is 1×10^{-4} g. How many drops are in the ocean?

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