

Scientific Notation:

A number is expressed in scientific notation when it is written as a product of a factor and a power of 10. The factor must be greater than or equal to 1 and less than 10.

A number in scientific notation is written as $a \times 10^n$, where $1 \leq a < 10$ and n is an integer.

Examples: $6.59 \times 10^4 = 6.59 \times 10,000 = 65,900$

$$4.81 \times 10^{-6} = 4.81 \times 0.000001 = 0.00000481$$

Example: Express each number in standard notation.

Example 1 Express 3.52×10^4 in standard notation.

$$\begin{aligned} 3.52 \times 10^4 &= 3.52 \times 10,000 \\ &= 35,200 \end{aligned}$$

The decimal point moved 4 places to the right.

Example 2 Express 6.21×10^{-5} in standard notation.

$$\begin{aligned} 6.21 \times 10^{-5} &= 6.21 \times \frac{1}{10^5} \\ &= 6.21 \times 0.00001 \\ &= 0.0000621 \end{aligned}$$

The decimal point moved 5 places to the left.

Check your progress:

1) 2.45×10^8

Since the exponent is positive 8, we will move the decimal 8 places to the right.

$$2.45000000 \quad 245000000 \quad 245,000,000$$

2) 3×10^{-5}

Since the exponent is negative 5, we will move the decimal 5 places to the left.

Remember that the decimal is assumed to be to the right of the 3 since none is explicitly stated.

$$0.00003 \quad 0.00003$$

Example: Express each number in scientific notation

Example 3 Express 37,600,000 in scientific notation.

$$37,600,000 = 3.76 \times 10^7$$

The decimal point moved 7 places so that it is between the 3 and the 7. Since $37,600,000 > 1$, the exponent is positive.

Example 4 Express 0.0000549 in scientific notation.

$$0.0000549 = 5.49 \times 10^{-5}$$

The decimal point moved 5 places so that it is between the 5 and the 4. Since $0.0000549 < 1$, the exponent is negative.

Check your progress:

1) 30,500,000

We need one non-zero in front of the decimal, so we will need to move the decimal between the 3 and 0. Since the decimal is assumed to be after the last zero, we will move the decimal 7 places. The original number is greater than 1, so the exponent on the 10 will be positive.

$$30,500,000 \quad 3.05 \times 10^7$$

2) 0.000781

We need one non-zero in front of the decimal, so we will need to move the decimal between the 7 and 8. We will move the decimal 4 places. The original number is less than 1, so the exponent on the 10 will be negative.

$$0.000781 \quad 7.81 \times 10^{-4}$$

Example: Evaluate the expression. Express the result in scientific notation.

Example 1 Evaluate $(6.7 \times 10^3)(2 \times 10^{-5})$. Express the result in scientific and standard notation.

$$\begin{aligned} (6.7 \times 10^3)(2 \times 10^{-5}) &= (6.7 \times 2)(10^3 \times 10^{-5}) && \text{Associative Property} \\ &= 13.4 \times 10^{-2} && \text{Product of Powers} \\ &= (1.34 \times 10^1) \times 10^{-2} && 13.4 = 1.34 \times 10^1 \\ &= 1.34 \times (10^1 \times 10^{-2}) && \text{Associative Property} \\ &= 1.34 \times 10^{-1} \text{ or } 0.134 && \text{Product of Powers} \end{aligned}$$

The solution is 1.34×10^{-1} or 0.134.

Example 2 Evaluate $\frac{1.5088 \times 10^8}{4.1 \times 10^5}$. Express the result in scientific and standard notation.

$$\begin{aligned} \frac{1.5088 \times 10^8}{4.1 \times 10^5} &= \left(\frac{1.5088}{4.1} \right) \left(\frac{10^8}{10^5} \right) && \text{Associative Property} \\ &= 0.368 \times 10^3 && \text{Quotient of Powers} \\ &= (3.68 \times 10^{-1}) \times 10^3 && 0.368 = 3.68 \times 10^{-1} \\ &= 3.68 \times (10^{-1} \times 10^3) && \text{Associative Property} \\ &= 3.68 \times 10^2 \text{ or } 368 && \text{Product of Powers} \end{aligned}$$

The solution is 3.68×10^2 or 368.

Check your progress:

1) $(5 \times 10^{-8})(2.9 \times 10^2)$

$(5 \cdot 2.9) \times (10^{-8} \cdot 10^2) = 14.5 \times 10^{-6}$ We need one more place behind the decimal, so we will add one to the exponent. $1.45 \times 10^{-5} = 0.0000145$

2) $\frac{1.2789 \times 10^9}{5.22 \times 10^5}$

$\left(\frac{1.2789}{5.22} \right) \times \left(\frac{10^9}{10^5} \right) = 0.245 \times 10^4$ We need one fewer place behind the decimal, so we will subtract one from the exponent. $2.45 \times 10^3 = 2,450$

Practice

State whether the number is in scientific notation. Explain your reasoning.

- 1) 65.2×10^3
 The number is not in scientific notation. In order to be in scientific notation there must only be one non-zero in front of the decimal. We can put this in scientific notation by putting one more number behind the decimal and adding one to the exponent on the 10.
 6.52×10^4

Express the number in standard notation.

- 2) 2×10^{-8}
 0.00000002
- 3) 4.59×10^3
 $4,590$
- 4) 7.183×10^{14}
 $718,300,000,000,000$
- 5) 3.6×10^{-5}
 0.000036

Express the number in scientific notation.

- 6) 56,700,000
 5.67×10^7
- 7) 0.00567
 5.67×10^{-3}
- 8) 0.00000000004
 4×10^{-11}
- 9) 3,002,000,000,000,000
 3.002×10^{15}

Evaluate. Express each result in scientific notation and in standard notation.

$$10) (5.3 \times 10^2)(4.1 \times 10^5)$$

$$(5.3 \cdot 4.1) \times (10^2 \cdot 10^5)$$

$$21.73 \times 10^7$$

$$2.173 \times 10^8 = 217,300,000$$

$$11) (2 \times 10^{-5})(9.4 \times 10^{-3})$$

$$(2 \cdot 9.4) \times (10^{-5} \cdot 10^{-3})$$

$$18.8 \times 10^{-8}$$

$$1.88 \times 10^{-7} = 0.000000188$$

$$12) \frac{1.5 \times 10^2}{2.5 \times 10^{12}}$$

$$\left(\frac{1.5}{2.5}\right) \times \left(\frac{10^2}{10^{12}}\right)$$

$$0.6 \times 10^{-10}$$

$$6 \times 10^{-11} = 0.00000000006$$

$$13) \frac{1.25 \times 10^4}{2.5 \times 10^{-6}}$$

$$\left(\frac{1.25}{2.5}\right) \times \left(\frac{10^4}{10^{-6}}\right)$$

$$0.5 \times 10^{10}$$

$$5 \times 10^9 = 5,000,000,000$$