Prime Factorization and Exponents Lesson #6:
Scientific Notation

Scientific notation is included as an application of powers with integral exponents.

Scientific Notation - Large Numbers

2.6×10^5

The 2016 census shows Canada has over 260 000 First Peoples' languages speakers.

The distance from Earth to the sun is approximately 93 000 000 miles. 9.3×10^7

The number of molecules of a gas per m^3 is approximately 27 000 000 000 000 000 000.

All these large numbers are written in standard decimal notation and it would be easy when 2.7×10^{19} writing out these numbers to make a mistake with the number of zeros.

Scientific Notation is a way of writing numbers that are too large or too small to be conveniently written in standard decimal notation. Scientists, engineers and mathematicians, often use scientific notation to represent numbers and use the properties of exponents to simplify calculations.

In scientific notation all numbers are written in the form $a \times 10^n$,
where the exponent, n, is an integer and the coefficient, a, is greater than or equal to 1 but less than 10. i.e. $1 \le a < 10$.

The number 32 000 in standard decimal notation can be written in product form as $3.2 \times 10 \times 10 \times 10 \times 10$ or in scientific notation as 3.2×10^4.

32000

$32000 \rightarrow 3.2 \times 10^4$

Class Ex. #1 Complete the following table.

Standard Notation	Expanded Form	Scientific Notation
61 500	$6.15 \times 10 \times 10 \times 10 \times 10$	6.15×10^4
500 000	$5 \times 10 \times 10 \times 10 \times 10 \times 10$	5×10^5
46.3	4.63×10	4.63×10^1
281	$2.81 \times 10 \times 10$	2.81×10^2
700000	$7 \times 10 \times 10 \times 10 \times 10 \times 10$	7×10^5
920	$9.2 \times 10 \times 10$	9.2×10^2
1400000	$1.4 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$	1.4×10^6

Class Ex. #2 Complete the following statements from the top of the page using scientific notation.

a) The 2016 census shows Canada has over 2.6×10^5 First Peoples' languages speakers.

b) The distance from Earth to the sun is approximately 9.3×10^7 miles.

c) The number of molecules of a gas per m^3 is approximately 2.7×10^{19}.

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Class Ex. #3 Convert the following numbers from scientific notation to standard notation.

a) 3.8×10^7 b) 2.51×10^{12} c) 2.9×10^3

$38,000,000$ $2,510,000,000,000$ 2900

Class Ex. #4 Simplify and write in scientific notation.

a) $7.1 \times 10^2 \times 1000$ b) $6.98 \times 10^7 \times 10^1$ c) $\dfrac{5 \times 10^6}{1000}$

$10 \times 10 \times 10 = 10^3$ 6.98×10^8

$7.1 \times 10^{2+3} = 7.1 \times 10^5$

$= \dfrac{5 \times 10^6}{10^3} = 5 \times 10^{6-3} = \boxed{5 \times 10^3}$

Complete Assignment Questions #1 - #5

Scientific Notation - Small Numbers

2.51×10^{-5}

Scientific Notation - Small Numbers

An inch is about 0.000 025 4 km. 2.54×10^{-5}

The mass of a particle of dust is about 0.000 000 000 75 kg. 7.5×10^{-10}

The mass of an electron is about 0.000 000 000 000 000 000 000 000 000 9 g.

All these small numbers are written in standard decimal notation, and again it would be easy when writing out these numbers to make a mistake with the number of zeros.

The number 0.000 63 in standard decimal notation can be written in the form

$$\frac{6.3}{10 \times 10 \times 10 \times 10} \quad \text{or} \quad \frac{6.3}{10^4} \quad \text{which is equivalent to} \quad 6.3 \times 10^{-4}.$$

Small # = negative exponents

Class Ex. #5 Complete the following table.

Standard Notation	Expanded Form	Scientific Notation
0.000 53	$\dfrac{5.3}{10 \times 10 \times 10 \times 10}$	5.3×10^{-4}
0.000 000 07	$\dfrac{7}{10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10}$	7×10^{-8}
0.0029	$\dfrac{2.9}{10 \times 10 \times 10}$	2.9×10^{-3}
0.0000071	$\dfrac{7.1}{10 \times 10 \times 10 \times 10 \times 10 \times 10}$	7.1×10^{-6}
0.0031	$\dfrac{3.1}{10 \times 10 \times 10}$	3.1×10^{-3}
0.000085	$\dfrac{8.5}{10 \times 10 \times 10 \times 10}$	8.5×10^{-5}

Class Ex. #6

Complete the following statements from the beginning of this section using scientific notation.

a) An inch is about 2.54×10^{-5} kilometres.

b) The mass of a particle of dust is about 7.5×10^{-10} kg.

c) The mass of an electron is about 9×10^{-28} g.

Class Ex. #7

a) Explain why 0.4×10^{-8} is not written in scientific notation.

this must be bigger than 1 but smaller than 10

b) Write 0.4×10^{-8} in scientific notation.

$$4 \times 10^{-1} \times 10^{-8} = 4 \times 10^{-1+(-8)} = \boxed{4 \times 10^{-9}}$$

Complete Assignment Questions #6 - #10

Scientific Notation on a Calculator
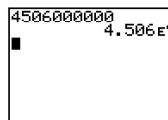
Using the Sci Mode

The `Sci` mode of a graphing calculator may be used to express numbers in scientific notation.

For example, use the following procedure to convert the approximate average distance that Neptune is from the sun (4 506 000 000 km):

1. Press [MODE], scroll right to "`Sci`", and press [ENTER].

```
Normal Sci Eng
Float 0123456789
Radian Degree
Func Par Pol Seq
Connected Dot
Sequential Simul
Real a+bi re^θi
Full Horiz G-T
```

2. Then "`QUIT`" by pressing [2nd] [MODE].

```
4506000000
          4.506E9
█
```

3. Enter the number 4 506 000 000 and press [ENTER].

The number `4.506E9` is to be written 4.506×10^{9} as an answer.

Note

To convert back to standard notation, set the graphing calculator back to "`Normal`" mode, input the number 4.506×10^{9}, and press [ENTER].

```
4.506*10^9
        4506000000
█
```
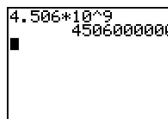
Using the EE feature

The `EE` feature represents "$\times 10^n$" on the calculator.
This feature may be useful in saving time.

Example: Use the following procedure to write the product $(4.25 \times 10^6) \times (3.65 \times 10^{-4})$
in scientific notation and in standard notation.

1. Place the calculator into scientific mode (`Sci`).

2. • Access the `EE` feature by pressing | 2nd | | , |
(the display will only show one `E`).
• Press 4.25 | 2nd | | , | 6 | × | 3.65 | 2nd | | , |
| (-) | 4 | ENTER | . The answer 1.55125×10^3 is
displayed.

```
4.25E6*3.65E-4
          1.55125E3
■
```
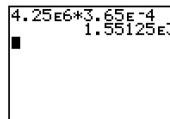
3. To give the answer in standard notation, place the calculator in
normal mode (`Normal`) and repeat steps 1 and 2 above.

```
4.25E6*3.65E-4
            1551.25
■
```
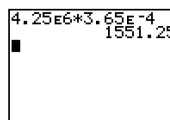
Note • Sometimes a calculation is so large or small that the calculator
automatically displays the answer in scientific notation, regardless of
the mode it is in. To convert back to standard notation you will
have to convert back manually.

```
0.0000005*0.0000
0045
           2.25E-13
■
```
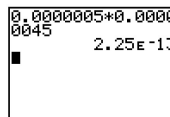
Class Ex. #8 Use a calculator to:

a) Write the product $(3.5 \times 10^5) \times (2.6 \times 10^9)$ in scientific notation.

b) Write the quotient $\dfrac{7.5 \times 10^{-17}}{5 \times 10^{-9}}$ in standard notation.

Complete Assignment Questions #11 - #16

Assignment

1. Complete the following table.

Standard Notation	Expanded Form	Scientific Notation
151 000		
23.4		
32 000		
	$8.3 \times 10 \times 10 \times 10 \times 10 \times 10$	
	$7.3 \times 10 \times 10$	
		8.4×10^2
		6.2×10^3

2. Express each number in scientific notation.

		6.2×10^3

2. Express each number in scientific notation.

a) 2 300 **b)** 7 580 000 **c)** 41 000 000 000

d) 53.1 **e)** 4 320 000 000 000 **f)** 7.6

3. Express the number of km in scientific notation.

a) Mercury has an approximate average distance of 57.9 million km from the sun. **b)** Saturn has an approximate average distance of 1.4 billion km from the sun.

l to change

4. Express each number in standard notation.

23 784

a) 1.8×10^{12} **b)** 6.73×10^5 **c)** 9.99×10^7

d) Mars has an approximate average distance of 2.2794×10^8 km from the sun.

e) The Treaty 11 Land Agreement signed between First Nations and the Canadian Government covered approximately 9.5×10^5 km^2 of land.

agreement.

9. Express each number in standard notation.
    a) 2.7×10^{-3} **b)** 1.28×10^{-4} **c)** 5.67×10^{6} **d)** 8.9×10

10. Express each of the following in scientific notation.
    a) 23.2×10^{5} **b)** 0.7×10^{3} **c)** 0.089×10^{-7} **d)** 45.6×10^{-9}

11. Using your calculator answer the following in scientific notation.
    a) $(3.6 \times 10^{8})(4.2 \times 10^{-5})$ **b)** $(1.8 \times 10^{5}) \div (3.2 \times 10^{2})$

    c) $(0.089 \times 10^{-3})(0.1 \times 10^{-8})$ **d)** $(23.1) \div (0.5 \times 10^{8})$

12. Using your calculator answer the following in standard notation.
    a) $(4.3 \times 10^{2})(2.4 \times 10^{-7})$ **b)** $(8.1 \times 10^{2}) \div (0.75 \times 10^{-2})$

    c) $(0.05 \times 10^{-3})(2.5 \times 10^{-3})$ **d)** $(6.8) \div (0.85 \times 10^{7})$

Multiple Choice

13. The tallest totem pole in Canada is located in Alert Bay, British Columbia.
    The traditional figures on the pole represent many of the families that belong to the
    Kwakwaka'wakw Nation and include the Bear, the Salmon, and the Whale.
    It is approximately 5640 cm high. Written using scientific notation, the height of the
    totem pole, in cm, is approximately

    A. 5.64×10^{2}
    B. 56.4×10^{2}
    C. 5.64×10^{3}
    D. 0.564×10^{4}

14. The length of the River Nile in Africa, is approximately 6 695 000 m. When this number
    is written in scientific notation in the form $a \times 10^{n}$, the value of n is

    A.   –6   **B.**   3   **C.**   6   **D.**   7

15. In January 2018, the highest grossing movie of all time was "Avatar", with world-wide takings of approximately 2 790 million dollars. In scientific notation, the number of dollars grossed by this movie is

A. 2.79×10^{10} **B.** 2.79×10^{9} **C.** 2.79×10^{6} **D.** 2.79×10^{3}

Numerical Response **16.** The speed of light is 3×10^{8} m/s. The sun is 1.5×10^{11} metres from the earth. If the number of seconds it takes for light to reach the earth is expressed in scientific notation in the form $a \times 10^{n}$, the value of $a + n$ is _____ .

(Record your answer in the numerical response box from left to right)

Answer Key

1.

Standard Notation	Expanded Form	Scientific Notation
151 000	$1.5 \times 10 \times 10 \times 10 \times 10$	1.51×10^{5}
23.4	2.34×10	2.34×10^{1}
32 000	$3.2 \times 10 \times 10 \times 10$	3.2×10^{4}
830 000	$8.3 \times 10 \times 10 \times 10 \times 10$	8.3×10^{5}
730	$7.3 \times 10 \times 10$	7.3×10^{2}
840	$8.4 \times 10 \times 10$	8.4×10^{2}
6 200	$6.2 \times 10 \times 10 \times 10$	6.2×10^{3}

6.

Standard Notation	Expanded Form	Scientific Notation
0.000 000 9	$\frac{9}{10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10}$	9×10^{-7}
0.000 001	$\frac{1}{10 \times 10 \times 10 \times 10 \times 10 \times 10}$	1×10^{-6}
0.000 035	$\frac{3.5}{10 \times 10 \times 10 \times 10 \times 10}$	3.5×10^{-5}
0.99	$\frac{9.9}{10}$	9.9×10^{-1}
0.069	$\frac{6.9}{10 \times 10}$	6.9×10^{-2}
0.000 85	$\frac{8.5}{10 \times 10 \times 10 \times 10}$	8.5×10^{-4}

2. a) 2.3×10^{3} **b)** 7.58×10^{6} **c)** 4.1×10^{10}
d) 5.31×10^{1} **e)** 4.32×10^{12} **f)** 7.6×10^{0}
3. a) 5.79×10^{7} km **b)** 1.4×10^{9} km
4. a) 1 800 000 000 000 **b)** 673 000 **c)** 99 900 000
d) 227 940 000 **e)** 950 000
5. a) 5.7×10^{7} **b)** 9.843×10^{9} **c)** 6.1×10^{4} **d)** 5×10^{1}
6. See table above
7. a) 1 to the left **b)** 5 to the left **c)** 3 to the right **d)** 1 to the right **e)** 8 to the left
8. a) 2.3×10^{-5} **b)** 5×10^{-3} **c)** 8.725×10^{-7} **d)** 7.93×10^{4} **e)** 6×10^{-1}
f) 7.89×10^{8} **g)** 5.94×10^{-6} **h)** 2.51×10^{-2} **i)** 8.13×10^{7}
9. a) 0.002 7 **b)** 0.000 128 **c)** 5 670 000 **d)** 89
10. a) 2.32×10^{6} **b)** 7×10^{2} **c)** 8.9×10^{-9} **d)** 4.56×10^{-8}
11. a) 1.512×10^{4} **b)** 5.625×10^{2} **c)** 8.9×10^{-14} **d)** 4.62×10^{-7}
12. a) 0.000 103 2 **b)** 108 000 **c)** 0.000 000 125 **d)** 0.000 000 8
13. C **14.** C **15.** B **16.** | 7 | | | |