

N3-1 Scientific Notation

- scientific notation

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Summary

Very large and very small numbers are often expressed in scientific notation. This consists of a number between 1.0 and 9.999 multiplied by an integer power of 10.

To convert scientific notation to decimal notation (normal numbers), just take the first part of the scientific notation and move the decimal point the appropriate number of places left or right according to the power. To convert the other way, place the decimal point immediately after the first non-zero digit, then multiply by the power of 10 needed to get the original decimal number.

Calculators use scientific notation for very large or small numbers. They show them in different ways. Numbers in scientific notation can be entered into a calculator also.

Lead-In

Take a scientific calculator and use it to work out $2\,000\,000 \times 3\,000\,000$. As you will know the answer is 6 000 000 000 000. But the calculator won't have enough display space for that number, so it gives is a different way.

Do a few similar calculations and try to work out how to read the answers it gives.

Then do the same with $0.000\,003 \times 0.000\,002$

Learn

Very Large and Very Small Numbers

The mass of the Earth is about 6 000 000 000 000 000 000 tonnes.

The mass of a hydrogen atom is about 0.000 000 000 000 000 000 000 001 673 kg.

Another way to think about it is that 10^7 is 1.0×10^7 , which is 1.0 with the decimal point moved 7 places to the right, i.e. 10 000 000.0.

Going the other way, 100 000 000 000.0 is 1.0 with the decimal point moved 11 places to the right, i.e. 1.0×10^{11} .

In the same way 10^{-5} is 1.0×10^{-5} , which is 1.0 with the decimal point moved 5 places to the left, i.e. 0.000 01.

Going the other way, 0.000 000 01 is 1.0 with the decimal point moved 8 places to the left, i.e. $1.0 \div 10^8$ i.e. 1.0×10^{-8} .

Scientific Notation

1.0×10^4 and 1.0×10^{-19} are called scientific notation. Note that, in scientific notation, we always use a \times , never a \div , so $1.0 \div 10^6$ is not scientific notation, even though it says the same thing as 1.0×10^{-6} .

We can also write numbers like 627 000 000 in scientific notation. 627 000 000 is 6.27×10^8 .

Likewise with 0.000 002 63. This is 2.63×10^{-6} .

Scientific notation consists of two parts: a decimal fraction and a power of 10. By convention, the decimal fraction is always between 1.0 and 9.99999..., i.e. it always has one digit before the decimal point. So 21.3×10^6 is not scientific notation. Nor is 0.4×10^{-8} . These numbers should be written as 2.13×10^7 and as 4×10^{-9} .

The normal way of writing numbers is often called 'decimal notation' when we want to distinguish it from scientific notation.

Changing Scientific Notation to Decimal Notation

To change 4.67×10^{-3} to decimal notation, just move the decimal point 3 places to the left to get 0.004 67. Likewise for 1.9×10^5 , we move the decimal point 5 places to the right to get 190 000.

Changing Decimal Notation to Scientific Notation

To change 437 800 to scientific notation, we put the decimal point after the first digit (4.378 00), then see how many places we have to move the decimal point to get the number we want. In this case it has to move 5 places to the right, so the number is 4.378×10^5 . Likewise for 0.000 000 000 026, we get 2.6, then see that we have to multiply this by 10^{-11} to get 0.000 000 000 026. So the number is 2.6×10^{-11} .

Practice

Q1 Complete the following tables:

Long form	Index form
100 000 000	
	10^{13}
0.000 01	
	10^{-9}
0.000 000 000 01	
	10^{-3}
100	
	10^1
1	
	10^{-1}
0.001	
	10^5

Scientific notation	Decimal notation
5.0×10^7	
	600 000
2.82×10^4	
	45 700
9.461×10^{-10}	
	0.000 034 51
3.01×10^{-2}	
	0.002
8.0×10^{-1}	
	6.91
3.71191×10^3	
	0.41

In doing Q1, you might have noticed that the number of zeros is the same as the index for positive indices, but this is only the case for negative indices if you include the zero before the decimal point.

Scientific notation on your calculator

Scientific calculators use scientific notation for very large and very small numbers. But not all write it the way we write it on paper. Most use one of two ways of writing it.

5.4×10^{11} is written as 5.4^{11} or as $5.4 \text{ E } 11$. 2.17×10^{-14} is written as 2.17^{-14} or as $2.17 \text{ E } -14$. Check out how your calculator shows it by typing in something like $0.000\ 024 \div 10\ 000\ 000$

Scientific calculators also allow you to enter numbers in scientific notation. Usually there is a button marked EXP or E or something similar. To enter 3.4×10^5 press $3.4 \text{ EXP } 5$.

Different calculators have different ways of entering negative numbers. With some, you enter the positive number then press a key marked +/- . With others, there is a negative key marked (-) . Just press this before entering the number.

Use your calculator to work out $(2.49 \times 10^{-6}) \div (3 \times 10^3)$ and make sure you can interpret the answer as 8.3×10^{-10} .

Practice

Q2 Perform the following calculations using the scientific notation functions on your calculator). Give your answers in proper scientific notation.

- (a) $4.7 \times 10^6 \times 1.83 \times 10^2$ (b) $6.12 \times 10^7 \div (3.06 \times 10^3)$
(c) $1.2 \times 10^{-4} \times 2 \times 10^4$ (d) $6 \times 10^{42} \times 1 \times 10^{18}$
(e) $9.22 \times 10^3 \div (4.9 \times 10^8)$ (f) $1.4 \times 10^8 + 2 \times 10^6$
(g) $5.32 \times 10^{12} - 3.4 \times 10^{-5}$ (h) $(3 \times 10^{10})^2$

Q3 Calculate the following. Give your answers in scientific notation.

- (a) $2.17 \times 10^6 \times 1.85 \times 10^{13}$ (b) $5 \times 10^{22} \div (1.06 \times 10^3)$
(c) $5.5 \times 10^{-7} \times 3 \times 10^7$ (d) $3.18 \times 10^{19} \times 1.06 \times 10^{16}$
(e) $4.35 \times 10^3 \div (4.2 \times 10^8)$ (f) $1.71 \times 10^6 + 2.4 \times 10^5$
(g) $6.99 \times 10^{19} - 5.4 \times 10^{-15}$ (h) $(2.2 \times 10^8)^4$

Solve

$$2 \times 10^4 \times 3 \times 10^5 = 6 \times 10^9$$

Try to find a way of predicting the product of two numbers given in scientific notation before you do them on your calculator. If you find a way, check it by doing a few in your head before you do them on the calculator.

Do the same thing for division.

Do the same for addition and subtraction.

Do the same for raising numbers in scientific notation to powers, for example

$$(2 \times 10^4)^3 = 8 \times 10^{12}$$

Revise

Revision Set 1

Q61 Convert the following to decimal notation:

- (a) 3.13×10^5 (b) 9×10^{-4} (c) 1×10^{13} (d) 2.2×10^1

Q62 Convert the following to scientific notation:

- (a) 450 000 (b) 0.000 000 023 1 (c) 4.8 (d) 0.7

Q63 Perform the following calculations (use a calculator), giving the answer in scientific notation.

- (a) $2.4 \times 10^{-8} \div (3 \times 10^{10})$ (b) $1 \times 10^2 + 3 \times 10^{-1}$

Answers

Q1

Long form	Index form
100 000 000	10^8
10 000 000 000 000	10^{13}
0.000 01	10^{-5}
0.000 000 001	10^{-9}
0.000 000 000 01	10^{-11}
0.001	10^{-3}
100	10^2
10	10^1
1	10^0
0.1	10^{-1}
0.001	10^{-3}
100 000	10^5

Scientific notation	Decimal notation
5.0×10^7	50 000 000
6×10^5	600 000
2.82×10^4	28 200
4.57×10^4	45 700
9.461×10^{-10}	0.000 000 000 946 1
3.451×10^{-5}	0.000 034 51
3.01×10^{-2}	0.0301
2×10^{-3}	0.002
8.0×10^{-1}	0.8
6.91×10^0	6.91
3.71191×10^3	3711.91
4.1×10^{-1}	0.41

Q2

- (a) 8.601×10^{19} (b) 2×10^4
 (c) 2.4×10^0 (d) 6×10^{60}
 (e) 1.88×10^{-5} (f) 1.42×10^8
 (g) 5.32×10^{12} (h) 9×10^{20}

Q3

- (a) 4.0145×10^8 (b) 4.717×10^{19}
 (c) 1.65×10^1 (d) 3.3708×10^{35}
 (e) 1.036×10^{-5} (f) 1.95×10^6
 (g) 6.99×10^{19} (h) 23.4256×10^{32}

Q61

- (a) 313 000 (b) 0.000 9 (c) 10 000 000 000 000 (d) 22

Q62

- (a) 4.5×10^5 (b) 2.31×10^{-8} (c) 4.8×10^0 (d) 7×10^{-1}

Q63

- (a) 8×10^{-19} (b) 1.003×10^2