2 Standard Form

The radius of the Earth is $6\,400\,000$ m.
The speed of light is $300\,000\,000$ m/s.
The charge of one electron is $-0.000\,000\,000\,000\,000\,000\,16$ C.

Big and small numbers are inconvenient to write down – scientists and engineers use standard form to make things clearer.

The above numbers in standard form look like this:

6.4×10^{6} (or 6.4 e 6 on a computer).

3.0×10^{8} (or 3.0 e 8 on a computer).

-1.6×10^{-19} (or -1.6 e -19 on a computer).

number in standard form = mantissa × power of ten

The mantissa is a number bigger than or equal to 1, but less than 10.

2.1 Which of the following numbers could be a mantissa?

(a) 9.5 – *Yes, it is larger than (or equal to)* 1 *and smaller than* 10
(b) 0.4 – *No, it is smaller than* 1
(c) 12.3 – *No, it is not less than* 10
(d) 0.2
(e) 1.2
(f) 1.0
(g) 10.3
(h) 0.04
(i) 10
(j) 5
(k) 7.6

Powers of ten are numbers you can make by starting with 1 and either multiplying or dividing as many times as you like by 10.

So 100, 0.01, $100\,000$, 10, 1 and $0.000\,1$ are all powers of ten,
but 30, 0.98 and $40\,000$ are not powers of ten.

Powers of ten can be written using exponents (e.g. 10^{2} rather than 100).

$10\,000 = 10 \times 10 \times 10 \times 10 = 10^4$	exponent $= 4$
$1\,000 = 10 \times 10 \times 10 = 10^3$	exponent $= 3$
$100 = 10 \times 10 = 10^2$	exponent $= 2$
$10 = 10 = 10^1$	exponent $= 1$
$1 = 10^0$	exponent $= 0$
$0.1 = 1/10 = 1/10^1 = 10^{-1}$	exponent $= -1$
$0.01 = 1/100 = 1/10^2 = 10^{-2}$	exponent $= -2$
$0.001 = 1/1000 = 1/10^3 = 10^{-3}$	exponent $= -3$

2.2 For the following numbers, decide if they are powers of ten and, if they are, write down the exponent. The first two have been done for you.

Number	Power of Ten	Exponent
30	✗	
100	✓	2
0.004	(a)	
0.01	(b)	
1 000 000 000	(c)	
0.000 000 1	(d)	

Note that the exponent counts the number of times the decimal point must be moved to get from its starting point before the number is turned into a mantissa:
e.g. $0.\underset{\rightarrow}{0}\,\underset{\rightarrow}{0}\,\underset{\rightarrow}{0}\,\underset{\rightarrow}{3}2 = 3.2 \times 10^{-4}$, as the decimal point must be moved 4 times to the right before it makes a 3.2.
Also $893 = 8\,\underset{\leftarrow}{9}\,\underset{\leftarrow}{3}.0 = 8.93 \times 10^2$ as the decimal point must be moved 2 times to the left before it makes an 8.93.

2.3 For each of the following numbers state how many times the decimal point must be moved (+ve to the left, −ve to the right) when making the numbers into a mantissa and the exponent of the 10 when in standard form.

(a) $0.000\,145$ (c) $345\,094$ (e) $69\,023$ (g) $0.011\,2$
(b) $153.034\,2$ (d) $0.003\,425\,39$ (f) $0.000\,002\,87$ (h) $56\,920.142\,2$

2.4 Write the following numbers as mantissa $\times$ power of ten, then write the exponent, and finally write them in standard form. The first two are done as examples.

Number	Mantissa $\times$ Power of 10	Standard Form
450 000	$4.5 \times 100\,000$	4.5×10^5
0.000 032	$3.2 \times 0.000\,01$	3.2×10^{-5}
300	(a)	(b)
0.026	(c)	(d)
390 000	(e)	(f)
6 700	(g)	(h)
0.000 000 062	(i)	(j)

2.5 Express the following numbers in standard form:

(a) 4 000 (c) 8.31 (e) 860 000 (g) 920 (i) 435 981 719

(b) 0.030 (d) 0.000 002 8 (f) 0.002 451 (h) 0.109 3 (j) 0.000 004 72

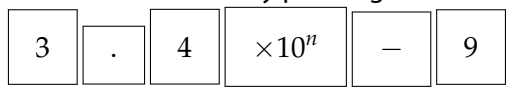
2.6 Write the following numbers in the normal way (e.g 3 300):

(a) 3×10^3 (d) 76×10^{-3} (g) 5.23×10^{-7} (j) 3.5×10^{-2}

(b) 2×10^{-2} (e) 3.54×10^0 (h) $3.218\,5 \times 10^{-4}$ (k) 8.54×10^7

(c) 6×10^1 (f) 9.73×10^8 (i) $6.983\,6 \times 10^5$ (l) 1.25×10^{-1}

You key 3.4×10^{-9} into a calculator by pressing



2.7 Do the following calculations on your calculator.

(a) $(3.0 \times 10^8) \div (6.6 \times 10^{-7})$

(b) $(3.0 \times 10^8) \div (3 \times 10^{-2})$

(c) $(3.0 \times 10^8) \div (2.3 \times 10^2)$

(d) $(3.0 \times 10^8) \div (5 \times 10^{-11})$