

**PLEASE RETURN THIS BOOKLET TO
KNOX WHEN FINISHED**

POWERS OF 10 AND SCIENTIFIC NOTATION
&
THE USE OF SCIENTIFIC CALCULATORS IN PHYSICS

Table of contents:

- Section 1 Powers of 10**
- Section 2 Scientific Notation**
- Section 3 The use of Scientific calculators in Physics**
- Section 4 Negative indexes**
- Section 5 Problems**

DO NOT WRITE ON THIS BOOKLET

POWERS OF 10

In physics we have to work with very large and some very small numbers. For example, an atom has a diameter of about 0.0000000001m while the Earth has a mass of about 60000000000000000000000000000 kg.

It would be very easy to miss out a zero or add an extra one by mistake.

This is where "Powers of 10" can come to the rescue.

You will know that $100 = 10 \times 10$.

This can also be written as 10^2 or 1×10^2 .

This number is "ten squared" or "one times ten to the power of two".

Similarly $1000 = 10 \times 10 \times 10 = 1 \times 10^3$ (one times 10 to the power three)

Try the following examples for yourself.

Use the space beside each question for any working that is required.

1 Write the following numbers as a power of 10:

(a) 10000

(b) 10000000

(c) 10000000000

(d) 100000000

2 Write the following powers of 10 as 'ordinary' numbers, with zeros:

(a) 1×10^9

(b) 1×10^5

(c) 1×10^7

(d) 1×10^{11}

Powers of 10 can also be used for other numbers for example:

$$400 = 4 \times 100 = 4 \times 10^2$$

$$\text{or } 700000 = 7 \times 100000 = 7 \times 10^5$$

3 Write the following numbers as a (single number) \times (a power of 10):

(a) 30000000

(b) 9000

(c) 600000000000

(d) Look back at the first paragraph of this Section.
Write down the mass of the Earth in the above form.

4 Write the following powers of 10 as 'ordinary' numbers, with zeros:

(a) 3×10^8

(b) 2×10^4

(c) 9×10^{14}

(d) 7×10^{10}

(e) 4×10^6

Answers to Section 1

- 1 (a) 1×10^4
(b) 1×10^7
(c) 1×10^{10}
(d) 1×10^8
- 2 (a) 1000000000
(b) 100000
(c) 10000000
(d) 1000000000000
- 3 (a) 3×10^7
(b) 9×10^3
(c) 6×10^{11}
(d) 6×10^{24} kg
- 4 (a) 300000000
(b) 20000
(c) 9000000000000000
(d) 70000000000
(e) 4000000

SCIENTIFIC NOTATION

Often the numbers we are are not as exact as those in Section 1, for example 740000. It can also be written as a power of 10:

$$740000 = 74 \times 10000 = 74 \times 10^4$$

Scientists have agreed on a way of writing these numbers.

The number **before** the power of 10 has to be a number **between 1 and 10**.

$$74000 = 74 \times 10000 = 7.4 \times 100000 = 7.4 \times 10^5$$

This method of writing numbers is called "**scientific notation**", in maths it is called the "**standard index form**".

1 Write the following numbers in scientific notation:

(a) 320000

(b) 7300

(c) 27000000

2 Change the following from standard index form to ordinary numbers:

(a) 3.9×10^2

(b) 4.7×10^8

(c) 9.8×10^4

This idea can be taken a stage further.

$$426500 = 4.265 \times 100000 = 4.265 \times 10^5$$

Note that 4.265 is still in the range between 1 and 10.

3 Write down the following in scientific notation.

- (a) 219000
- (b) 34620000
- (c) 14010

4 Write the following as ordinary numbers:

- (a) 9.12×10^4
- (b) 1.256×10^3
- (c) 4.1372×10^7

5 Consider the following problem. How far will light travel in 20 s?

The equation we will have to use is: distance = speed x time

Light travels at $300000000 \text{ ms}^{-1}$

From the equation distance = speed x time

substitution gives: distance = $3 \times 10^8 \times 20$

- (a) what is the answer to $2 \times 3 \times 5$?
- (b) what is the answer to $5 \times 2 \times 3$?
- (c) does it matter which order the numbers are multiplied together?
We can therefore say $3 \times 10^8 \times 20 = 3 \times 20 \times 10^8$
- (d) what is 3×20 ?

write this in scientific notation.

distance = $60 \times 10^8 \text{ m}$

This is the correct answer, though it is not in scientific notation.

- (e) write down the answer in scientific notation.

If you have a calculator we can obtain the answer faster.

Section 3 deals with how to answer similar questions to the one above using a calculator.

Answers to Section 2

- 1 (a) 3.2×10^5
(b) 7.3×10^9
(c) 2.7×10^7
- 2 (a) 390
(b) 470000000
(c) 98000
- 3 (a) 2.19×10^5
(b) 3.462×10^7
(c) 1.401×10^4
- 4 (a) 91200
(b) 1256
(c) 41372000
- 5 (a) 30
(b) 30
(c) NO
(d) 60
(e) 6×10^9 m

USING CALCULATORS IN PHYSICS

If you have a scientific calculator then follow through the instructions in **Section 3 (scientific calculators)**.

If you do *not* have a scientific calculator you will be shown how to tackle these questions on a non scientific one in **Section 3 (non scientific calculators)** page 11.

Section 3 (scientific calculators)

In the last problem the calculation was: distance = $3 \times 10^8 \times 20$

Enter the following on a scientific calculator:

3 **EXP** **8** **X** **2** **0** **=**

The **EXP** button means "x 10 to the power". On some calculators this button might read

EE or **E**

Check that you get the answer to the question at the end of Section 2.

Write down the number which is displayed.

Calculators may give the final answer in different ways.

Most calculators will give the answer as: **6. 09**

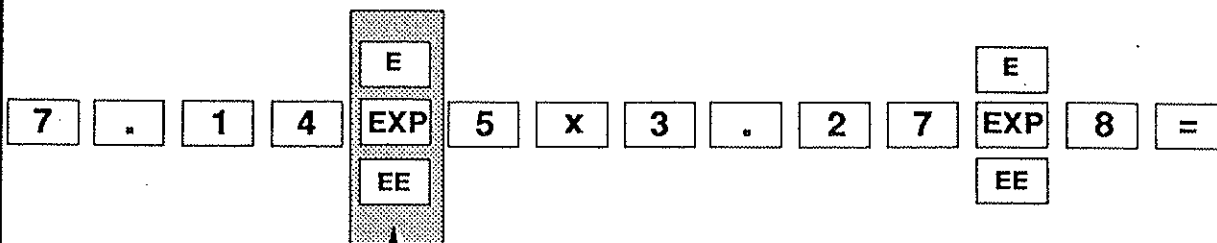
The number on the right is the power of 10 and the number on the left is the number between 1 and 10.

Therefore: **6. 09** means 6×10^9 .

Here is another example.

Find the answer to: $7.14 \times 10^5 \times 3.27 \times 10^8$

Press the buttons in the following sequence:



choose the button on
your calculator

Check that you get the answer: 2.33478×10^{14}

It is normally rounded off to two or three decimal places:

$$2.33 \times 10^{14} \text{ or } 2.335 \times 10^{14}.$$

Use a calculator to find the value of the following, rounding the final answer to three decimal places.

- 1 (a) $2.914 \times 10^5 \times 7.206 \times 10^8$
- (b) $5.644 \times 10^2 \times 4.112 \times 10^{14}$
- (c) $8.001 \times 10^3 \times 3.943 \times 10^6$
- (d) $3.142 \times 10^3 \times 6.201 \times 10^5$
- (e) $7.002 \times 10^{19} \times 3.019 \times 10^4$
- (f) $1.413 \times 10^{12} \times 7.114 \times 10^2$

Division

So far we have only multiplied two numbers together. The same method can be used for division.

For example to find the answer to: $\frac{5.9 \times 10^{15}}{7.8 \times 10^3}$

Press the following buttons in sequence:

5 . 9 EXP 1 5 ÷ 7 . 8 EXP 3 =

This should give the answer : 7.564×10^{11}

2. Calculate the following giving the answer in scientific notation to two places of decimals:

(a) $\frac{7.31 \times 10^{18}}{4.27 \times 10^3}$

(b) $(7.11 \times 10^{23}) / (9.74 \times 10^6)$

Note that $(7.11 \times 10^{23}) / (9.74 \times 10^6)$ is the same as $\frac{7.11 \times 10^{23}}{9.74 \times 10^6}$

(c) $\frac{5.97 \times 10^{12}}{6.33 \times 10^2}$

(d) $(9.44 \times 10^{16}) / (3.12 \times 10^3)$

(e) $\frac{7.21 \times 10^{12}}{2.19 \times 10^5}$

(f) $(6.31 \times 10^9) / (1.14 \times 10^2)$

NEGATIVE INDICES

We come across a problem using this rule. Follow through the following example.

$$\begin{aligned}\frac{9.317 \times 10^3}{4.631 \times 10^5} &= \frac{9.317}{4.631} \times \frac{10^3}{10^5} \\ &= 2.012 \times 10^{(3-5)} \\ &= 2.012 \times 10^{-2}\end{aligned}$$

What does 10^{-2} mean?

$$10^{-2} = \frac{10^3}{10^5} = \frac{1000}{100000} = \frac{1}{100} = \frac{1}{10^2}$$

Therefore 1×10^{-2} is same as $\frac{1}{10^2}$

$$1 \times 10^{-2} = \frac{1}{10^2} = \frac{1}{100}$$

What is this as a decimal?

If you are unsure, divide 1 by 100 on your calculator.

$$1 \times 10^{-2} = \frac{1}{10^2} = \frac{1}{100} = 0.01$$

Also: $0.001 = \frac{1}{1000} = \frac{1}{10^3} = 1 \times 10^{-3}$

Notice that: $0.0005 = 5 \times 0.0001 = \frac{5}{10000} = \frac{5}{10^4} = 5 \times 10^{-4}$

- 1 At the beginning of Section 1, the diameter of an atom was about 0.0000000001m. Write this in scientific notation.

2 Complete the table below to show that you understand negative powers of 10.

decimal	fraction	scientific notation
0.0001		
0.007		
0.0012		
	$\frac{1}{1000}$	
	$\frac{3}{100000}$	
	$\frac{47}{10000000}$	
		1×10^{-6}
		5×10^{-5}
		3.7×10^{-4}

3 Calculate the following, giving the answers to two decimal places.

(a) $(8.14 \times 10^{-3}) / (7.29 \times 10^5)$

(b) $\frac{2.35 \times 10^6}{9.18 \times 10^{13}}$

(c) $(4.99 \times 10^{-4}) / (2.55 \times 10^7)$

Answers to Section 4

1 $1 \times 10^{-10} \text{ m}$

2

decimal	fraction	scientific notation
0.0001	$\frac{1}{10000}$	1×10^{-4}
0.007	$\frac{7}{1000}$	7×10^{-3}
0.0012	$\frac{12}{10000}$	1.2×10^{-3}
0.001	$\frac{1}{1000}$	1×10^{-3}
0.00003	$\frac{3}{100000}$	3×10^{-5}
0.0000047	$\frac{47}{10000000}$	4.7×10^{-6}
0.000001	$\frac{1}{1000000}$	1×10^{-6}
0.00005	$\frac{5}{100000}$	5×10^{-5}
0.00037	$\frac{37}{100000}$	3.7×10^{-4}

- 3 (a) $1.12 \times 10^{-8} \text{ m}$
 (b) $2.56 \times 10^{-8} \text{ m}$
 (c) $1.96 \times 10^{-11} \text{ m}$

PROBLEM SHEET

Use a calculator to answer the following questions.

1 Write the following numbers in scientific notation:

(a) 300000

(d) 0.0007

(g) 0.0137

(b) 12340000

(e) 824.61

(h) 0.00101

(c) 75300

(f) 0.00229

2 Convert the following from scientific notation to decimal numbers:

(a) 3×10^7

(d) 7×10^{-3}

(g) 3.513×10^7

(b) 4.25×10^4

(e) 1.47×10^{-5}

(h) 6.123×10^{-6}

(c) 7.31×10^2

(f) 4.26×10^{-3}

3 Calculate the following, giving your answer in scientific notation and to three decimal places.

(a) $7.43 \times 10^3 \times 4.61 \times 10^7$

(b) $3.947 \times 10^8 \times 6.224 \times 10^4$

(c) $6.155 \times 10^7 / 5.136 \times 10^5$

(d) $2.015 \times 10^4 / 9.302 \times 10^7$

(e) 0.00714×13740000

(f) 217300000×0.00101

(g)
$$\frac{2.46 \times 10^7}{1.93 \times 10^9}$$

(h)
$$\frac{2.17 \times 10^3}{4.22 \times 10^{-6}}$$

(i) $0.000314 / 0.000721$

(j) $7.312 \times 10^7 / 0.0000414$

(k) $0.0019 / 7.31 \times 10^8$

(l) $8.975 \times 10^5 / 9.021 \times 10^{-7}$

4 Using the equations $s = \frac{d}{t}$ $d = s \times t$ or $t = \frac{d}{s}$ find the answers to the following:

(Note: speed of light = $3 \times 10^8 \text{ ms}^{-1}$).

- (a) How far away is the Sun, if it takes 500 s for the light from it to reach the Earth?
- (b) A star called Canis Majoris lies $8.2 \times 10^{16} \text{ m}$ from the Earth. How long does it take the light from this star to reach the Earth.
- (c) Find the speed of light in an optical fibre if it takes $2 \times 10^{-7} \text{ s}$ to travel a length of 40m.
- (d) How long does it take light to travel $1 \times 10^4 \text{ m}$ through air?

ANSWERS TO PROBLEM SHEET

- 1 (a) 3×10^5 (d) 7×10^{-4} (g) 1.37×10^{-2}
(b) 1.234×10^7 (e) 8.2461×10^2 (h) 1.01×10^{-3}
(c) 7.53×10^4 (f) 2.29×10^{-3}
- 2 (a) 30000000 (d) 0.007 (g) 35130000
(b) 42500 (e) 0.0000147 (h) 0.000006123
(c) 731 (f) 0.00426
- 3 (a) 3.425×10^{11}
(b) 2.457×10^{13}
(c) 1.198×10^2
(d) 2.166×10^{-4}
(e) 9.810×10^4
(f) 2.195×10^5
(g) 1.275×10^{-2}
(h) 5.142×10^8
(i) 4.355×10^{-1}
(j) 1.766×10^{12}
(k) 2.599×10^{-12}
(l) 9.949×10^{11}
- 4 (a) 1.5×10^{11} m
(b) 2.733×10^8 s = 8.7 years
(c) 2×10^8 ms⁻¹
(d) 3.33×10^{-5} s