

Student Name

Mathematics Stage 5 Core

NUMBERS OF ANY MAGNITUDE

Book 4 Express numbers in scientific notation

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OVERVIEW

SYLLABUS CONTENT

MA5-MAG-C-01 solves measurement problems by using scientific notation to represent numbers and rounding to a given number of significant figures

Express numbers in scientific notation

- Recognise the need for notation to express very large or very small numbers
- Represent numbers using scientific notation in practical contexts
- Order numbers expressed in scientific notation
- Represent numbers expressed in scientific notation as a decimal
- Estimate the value of calculations involving scientific notation by applying knowledge of index laws
- Solve problems with calculations involving scientific notation using digital tools

REVIEW OF PRIOR KNOWLEDGE

1 Complete the following:

	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}
Fraction	$\frac{1}{10}$				
Decimal					

2 Jackson is working out powers of 10. Explain why he is incorrect.

$$10^{-3} = -1000$$

.....

3 Complete the table. You can use your calculator to help you.

Power of 10	10^5	10^4	10^3	10^2	10^1	10^0	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}
Ordinary number	100 000	10 000			10	1	0.1	0.01			

- a Which powers of 10 are large?
- b Which powers of 10 are small?
- c Which powers of 10 are positive?
- d Which powers of 10 are negative?

4

- a Write one million as a power of 10.
- b Write one millionth as a power of 10.
- c What is the same about your answers? What is different?

SCIENTIFIC NOTATION (STANDARD FORM)

- **Scientific notation**, or **standard form**, shows very large or very small numbers.
- Scientific notation expresses numbers as a multiple of a **power of 10**.

Scientific Notation (Standard Form)	
$a \times 10^n$	
$\uparrow$ Number between 1 and 10	$\uparrow$ Any integer. Positive n : large number Negative n : small number

- Identify the largest place column to have value (i.e. the first significant figure), then treat that as the new counting unit.
 - 6 500 000 “6.5 million” 6.5×10^6
 - 300 000 “3 hundred thousands” 3×10^5
 - 0.004 35 “4.35 thousandths” 4.35×10^{-3}

Example Identify numbers written in scientific notation.

Determine whether these numbers are written in scientific notation.			
a 3×10^5	b 3×10^6	c 3×10^{67}	d $3 \times 10^{6.7}$
e $3 \times 10^{0.67}$	f 3×10^7	g 3×10^{-7}	h $3 \times 10^{-0.7}$
i 3×100^7	j 30×10	k 30×10^7	l 30×10^{-7}
m 0.3×10^7	n 3.3×10^7	o 3.0×10^7	p 30000
In $a \times 10^n$, what values can a take?			
.....			
In $a \times 10^n$, what values can n take?			
.....			

Key ideas

- Scientific notation and form refer to the same thing:
 $a \times 10^n$, where a is a number between and, and n is an

1 Decide whether these numbers have been written in scientific notation or not.

a	5.9×10^6	b	34×10^8	c	$8.97 \times 10\ 000$	d	5.03×10^{-9}
	yes		no		no		yes
e	28000	f	7×10^{-15}	g	0.85×10^4	h	2.006×10^{60}
	no		yes		no		yes

2 Complete the table.

Scientific notation	Expanded Form	Basic Numeral
5×10^3	5×1000	5 000
3×10^4	$3 \times 10\ 000$	30 000
2×10^5	$2 \times 100\ 000$	300 000
7×10^4	$7 \times 10\ 000$	70 000
4×10^5	$4 \times 100\ 000$	400 000
2×10^5	$2 \times 100\ 000$	200 000

3 Complete the table.

Scientific notation	Fraction	Basic Numeral
2×10^{-4}	$\frac{2}{10^4} = \frac{2}{10\ 000}$	0.0002
3×10^{-2}	$\frac{3}{100}$	0.03
5×10^{-3}	$\frac{5}{1000}$	0.005
8×10^{-2}	$\frac{8}{100}$	0.08
6×10^{-4}	$\frac{6}{10\ 000}$	0.0006
4×10^{-5}	$\frac{4}{100\ 000}$	0.00004

CONVERTING TO SCIENTIFIC NOTATION

1. Move the decimal point after the first non-zero digit.
2. Count digits between the new and old decimal points. This is the power of 10.
3. Write the power of 10:
 - a. Positive for large numbers,
 - b. Negative for small numbers.

3000000.

$$300000.0 \times 10^1$$

$$30000.00 \times 10^2$$

$$3000.000 \times 10^3$$

$$300.0000 \times 10^4$$

0.000032

$$00.00032 \times 10^{-1}$$

$$000.0032 \times 10^{-2}$$

$$0000.032 \times 10^{-3}$$

$$00000.32 \times 10^{-4}$$

Example Represent numbers using scientific notation.

246000

 2.46000

$$= 2.46 \times 10^5$$

Where do we move the decimal to?

We move the decimal to immediately after the first-..... digit.

0.00071

 0 0007.1

$$= 7.1 \times 10^{-4}$$

How do we know the power of 10?

The power of 10 is the number of between the old and new decimal.

Convert these numbers to scientific notation.

a 50 000

$$5 \times 10^4$$

b 452 000

$$4.52 \times 10^5$$

c 5300

$$5.3 \times 10^3$$

d 0.004

$$4 \times 10^{-3}$$

e 0.000 57

$$5.7 \times 10^{-4}$$

f 0.000 0132

$$1.32 \times 10^{-5}$$

Key ideas

1. To convert from decimal form to scientific notation:
 - a. Move the decimal point so it is after the first digit.
 - b. Count the digits between the new and old decimal point. This is the power of 10.
 - c. n is for large numbers and for small numbers.

1 Write these numbers in scientific notation.

a 26 000 2.6×10^4	b 670 6.7×10^2	c 219 000 2.19×10^5
d 63 000 000 6.3×10^7	e 7 540 000 7.54×10^6	f 35 3.5×10^1
g 718 000 000 7.18×10^8	h 90 300 9.03×10^4	i 66 120 000 000 6.612×10^{10}
j 1.2 million 1.2×10^6	k 7155 7.155×10^3	l 730 000 025 000 $7.300\,000\,25 \times 10^{11}$

2 Write each of these numbers in scientific notation.

a 0.12 1.2×10^{-1}	b 0.012 1.2×10^{-2}	c 0.0012 1.2×10^{-3}	d 0.000 12 1.2×10^{-4}
e 0.000 03 3×10^{-5}	f 0.000 032 3.2×10^{-5}	g 0.000 031 7 3.17×10^{-5}	

3 Write the following numbers in scientific notation.

a 7600 7.6×10^3	b 1 700 000 000 1.7×10^9	c 0.000 56 5.6×10^{-4}
d 0.000 067 8 6.78×10^{-5}	e 35 000 3.5×10^4	f 0.26 2.6×10^{-1}
g 590 000 5.9×10^5	h 6 800 000 6.8×10^6	i 0.000 000 812 8.12×10^{-7}
j 0.004 3 4.3×10^{-3}	k 310 000 000 3.1×10^8	l 0.092 9.2×10^{-2}

4 Express the following numbers in scientific notation.

- a** The number of hairs on a person's head is approximately 129 000.
 1.29×10^5 hairs
- b** The distance from Earth to the Sun is 152 000 000 km.
 1.52×10^8 km
- c** The diameter of a hydrogen atom is 0.000 000 002 54 cm.
 2.54×10^{-9} cm
- d** The size of the influenza virus is 0.000 000 26 m.
 2.6×10^{-7} m

CONVERTING TO DECIMAL FORM

- For $a \times 10^n$
- 1. Move the decimal left or right depending on the value of n .
 - If n is positive, move the decimal n places to the right.
 - If n is negative, move the decimal n places to the left.
- Remember:** big numbers have positive power, small numbers have negative power.

Example Represent numbers as decimal form.

6.48×10^5  $= 648\,000$	How do we know how many places to move the decimal? <i>The of 10 tells us how many places to move the decimal.</i>
3.51×10^{-6}  $= 0.000\,003\,51$	How do we know if it will be a very small or very large number? <i>n positive: number</i> <i>n negative: number</i>

Convert these numbers to decimal form.

a 3×10^4	b 5×10^{-2}	c 3.9×10^6
30 000	0.05	3 900 000
d 8.737×10^2	e 3.51×10^{-6}	f 2.71×10^{-5}
873.7	0.000 003 51	0.000 027 1

Key ideas

- To convert from scientific notation to decimal form:
 - Move the decimal point left or right depending on the value of
 If n is positive, move the decimal n places to the
 If n is negative move the decimal n places to the
 - Big numbers have power and small numbers have power.

1 Write these numbers in decimal form.

a 2×10^4 20 000	b 1.5×10^3 1500	c 3.82×10^5 382 000
d 1.79×10^4 17 900	e 9.91×10^6 9 910 000	f 6.5×10^2 650
g 2.274×10^5 227 400	h 6.5823×10^8 658 230 000	i 8×10^5 800 000

2 Write these numbers in decimal form.

a 2.4×10^{-3} 0.0024	b 1.56×10^{-4} 0.000 156	c 8.1×10^{-2} 0.081
d 7.685×10^{-6} 0.000 007 685	e 1.35×10^{-7} 0.000 000 135	f 7.6×10^{-1} 0.76
g 5.564×10^{-4} 0.000 556 4	h 2.367×10^{-6} 0.000 002 367	i 6×10^{-3} 0.006

3 Match the cards that are equal in value.

a 2.9×10^4	b 2.09×10^3	c 2.9×10^6	d 2.09×10^4
A 2900 000	B 29000	C 2090	D 20900

a – B, b – C, c – A, d – D

4 Write the following numbers in decimal form.

a 1.12×10^5 112 000	b 5.34×10^8 534 000 000	c 5.81×10^{-3} 0.00581
d 1.63×10^{-7} 0.000 000 163	e 2.4×10^2 240	f 3.5×10^{-4} 0.00035
g 7.9×10^{-6} 0.000 007 9	h 5.2×10^3 5200	i 8.678×10^7 86 780 000

5 Jackson says: " $2.3 \times 10^4 = 230\,000$ "

Explain why he is incorrect and write 2.3×10^4 in decimal form.

$2.3 \times 10^4 = 2.3 \times 10\,000 = 23\,000$

MIXED PRACTICE

FOUNDATION

1 Write $>$, $<$, or $=$ to compare each pair of numbers.

a 3×10^5 2×10^5

b 3×10^5 7×10^8

$>$ $<$

c 3×10^5 340 000

d 3×10^5 4×10^5

$<$ $<$

e 3×10^5 6×10^2

$>$ $..$

2 Compare these numbers using $<$, $>$, or $=$

a 4.5×10^3 4.2×10^3

b 7×10^4 55 000

$>$ $>$

c 8.95×10^5 2.8×10^6

d 1.03×10^{-2} 1.5×10^{-2}

$<$ $<$

e 1.03×10^{-2} 1.5×10^{-3}

f 1.03×10^{-2} 1.5×10^{-1}

$>$ $<$

3 Arrange the following sets of numbers in ascending order.

a

6.3×10^5 , 0.0056×10^8 , 672 000,

b

0.000234, 2.341×10^{-3} , 234.01×10^{-5}

0.0056×10^8 , 6.3×10^5 , 672,000

0.000234, 234.01×10^{-5} , 2.341×10^{-3}

4 Write these numbers from largest to smallest.

2.41×10^6 , 24.2×10^5 , 0.239×10^7 , 2421×10^3 , 0.02×10^8

2421×10^3 , 24.2×10^5 , 2.41×10^6 , 0.239×10^7 , 0.02×10^8

5 Here are four number cards:

A 1.6×10^4

B 1.6×10^5

C 1.7×10^4

D 1.7×10^6

a Which card is 10 times greater than A?

.....

B

b Which card is 100 times smaller than D?

.....

C

c E is a thousand times greater than A. Write E in scientific notation.

.....

1.6×10^7

6 Choose the correct answer to each calculation,

a $6 \times 10^4 + 3 \times 10^5$

9×10^9

9×10^5

63 000

360 000

360 000

b $6 \times 10^5 - 3 \times 10^4$

3×10^1

3×10^5

630 000

570 000

570 000

c $6 \times 10^{-2} - 3 \times 10^{-4}$

3×10^{-6}

3×10^2

0.0597

0.00597

0.0597

d $6 \times 10^3 + 3 \times 10^{-3}$

9×10^0

6000.003

6000.0003

6.3×10^3

6000.003

e $6 \times 10^3 - 1 \times 10^{-3}$

5×10^{-3}

6000.001

5999.999

5×10^0

5999.999

7 Rewrite each number in scientific notation.

a i 30×10^3

3×10^4

ii 30×10^4

3×10^5

iii 30×10^5

3×10^6

iv 30×10^{27}

3×10^{28}

b i 80×10^7

8×10^8

ii 800×10^7

8×10^9

iii 8000×10^7

8×10^{10}

iv $800\,000 \times 10^7$

8×10^{12}

c i 20×10^3

2×10^4

ii 12×10^3

1.2×10^4

iii 23×10^3

2.3×10^4

iv 105×10^3

1.05×10^5

d i 80×10^{14}

8×10^{15}

ii 97×10^{14}

9.7×10^{15}

iii 230×10^{14}

2.3×10^{16}

iv 10.5×10^{14}

1.05×10^{15}

e i 1250×10^{-3}

1.25

ii 125×10^{-3}

1.25×10^{-1}

iii 12.5×10^{-3}

1.25×10^{-2}

iv 0.125×10^{-3}

1.25×10^{-4}

8 Work out the missing numbers.

a $(12 \times 10^9) \div (2 \times 10^{\boxed{}}) = 6 \times 10^3$

6

b $(6 \times 10^{\boxed{}}) \div (4 \times 10^3) = 1.5 \times 10^5$

8

c $(2.4 \times 10^2) \div (2 \times 10^{\boxed{}}) = 1.2 \times 10^{-3}$

5

d $(2.4 \times 10^{\boxed{}}) \div (2 \times 10^2) = 1.2 \times 10^{-3}$

-1

9 Using index laws, calculate the following and express your answer in scientific notation.

a $(2 \times 10^3) \times (3 \times 10^6)$

b $(7 \times 10^{-5}) \times (4 \times 10^{-2})$

$$6 \times 10^9$$

$$2.8 \times 10^{-2}$$

c $\frac{8 \times 10^5}{2 \times 10^{-2}}$

d $\frac{7 \times 10^{-7}}{7 \times 10^{-3}}$

$$4 \times 10^7$$

$$1 \times 10^{-4}$$

10 A bag of ants is 4 kg. Each ant is roughly 0.000 002 kg.

a First, express 0.000 002 kg in scientific notation:

$$2 \times 10^{-6}$$

b Determine how many ants are in each bag.

You shouldn't need a calculator if you know your index laws!

$$\frac{4}{2 \times 10^{-6}} = 2 \times 10^6$$

c If an average ant weighs 2 mg and there are around 20 quadrillion (20×10^{15}) ants in the world, how much do all the ants in the world weigh?

$$(20 \times 10^{15}) \times (2 \times 10^{-6}) = 40 \times 10^9 = 4 \times 10^{10} \text{ kg}$$

d If an average human weighs 60 kg and there are 8 billion (8×10^9) humans, how much do all the humans in the world weigh?

$$60 \times (8 \times 10^9) = 480 \times 10^9 = 4.8 \times 10^{11} \text{ kg}$$

e Do all the ants in the world weigh more or all the humans?

humans

11 An average adult has about 20 000 000 000 000 red blood cells. Each red blood cell has a mass of about 0.000 000 000 1 gram. Work out the total mass of the red blood cells in an average adult. Give your answer in scientific notation.

$$(2 \times 10^{13}) \times (1 \times 10^{-10}) = 2 \times 10^3 \text{ g}$$

12 The speed of light is 3×10^8 m/s. The distance to the sun is 1.5×10^{11} m. Calculate the time, in minutes, it takes for light to travel from the sun to Earth.

$$(1.5 \times 10^{11}) \div (3 \times 10^8) = 8.330 \text{ mins}$$



Use a calculator for the following questions.

- 13** If $y = 0.5x^2$, calculate the value of y in scientific notation when $x = 9.8 \times 10^{-3}$

$$4.02 \times 10^{-5}$$

- 14** Given that $V = \frac{r}{\sqrt{h}}$, find the value of r in scientific notation when $V = 5 \times 10^4$ and $h = 9 \times 10^6$

$$1.5 \times 10^8$$

- 15** Find x in scientific notation, given that $x^3 = 8 \times 10^{12}$

$$2 \times 10^4$$

- 16** Use the formula $E = mc^2$ to find c in scientific notation, given that $E = 4.05 \times 10^{18}$ and $m = 45$.

$$3 \times 10^8$$

17 2009 HSC Standard 2 Band 6

The mass of a sample of microbes is 50 mg.

There are approximately 2.5×10^6 microbes in the sample.

In scientific notation, what is the approximate mass in grams of one microbe?

$$0.05 \text{ g} \div (2.5 \times 10^6)$$

$$2 \times 10^{-8} \text{ g}$$

- 18** Find the value of each letter,

a p and q are integers.

$$(p \times 10^7) + (q \times 10^2) = 50\,000\,400$$

$$p = 5, q = 4$$

b n is a positive integer less than 10

$$(n \times 10^8) - (n \times 10^5) = 399\,600\,000$$

$$n = 4$$

c x and y are integers.

$$x - y = 1$$

$$(y \times 10^{-2}) - (6 \times 10^{-3}) = 0.044$$

$$y = 5, x = 6$$

SCIENTIFIC NOTATION AND SIGNIFICANT FIGURES

- For a number written in scientific notation $a \times 10^n$, every digit of a is significant.
 - 1.02×10^5 has 3 significant digits.
 - 6.0×10^{-3} has 2 significant digits.
- Rounding to a significant figure and scientific notation:
 - Write the number in scientific notation $a \times 10^n$
 - Round a to the required significant figure.

Example Write numbers in scientific notation and round to a significant figure.

Write these numbers using scientific notation to three significant figures.	
2 183 000 1.  2.183 000 2.183×10^6 2. 2.18×10^6	0.001 948 2 1.  0 001.9482 1.9482×10^{-3} 2. 1.95×10^{-3}

Write these numbers using scientific notation to three significant figures.

a 487 830

1.

2.

$$4.88 \times 10^5$$

b 0.06531

1.

2.

$$6.53 \times 10^{-2}$$

1 State the number of significant figures given in these numbers.

a 0.272	b 1007	c 0.20	d 1.3
3	4	2	2
e 1.3×10^3	f 4.21×10^3	g 2.905×10^{-2}	h 1.700×10^{-6}
2	3	4	4

2 Write these numbers using scientific notation and three significant figures.

a 242 300	b 2 829	c 0.000 342 76
2.42×10^5	2.83×10^3	3.43×10^{-4}
d 0.006 859	e 0.172 046	f 326.042
6.86×10^{-3}	1.72×10^{-1}	3.26×10^2

3 Write using scientific notation rounding to the number of significant figures in brackets.

a 47 760 (3)	b 4 833 160 (4)	c 929.502 (1)
4.78×10^4	4.833×10^6	9×10^2
d 0.002 81 (2)	e 0.000 101 (1)	f 37.66 (2)
2.8×10^{-3}	1×10^{-4}	3.8×10^1

4 **2020 HSC Standard 2 Band 5**

What is 0.002073 expressed in scientific notation with two significant figures?

- A. 2.07×10^{-2}
- B. 2.1×10^{-2}
- C. 2.07×10^{-3}
- D. 2.1×10^{-3}

D

5 **2019 HSC Advanced Band 3**

What is the value of π^{10} to two significant figures.

- A. 9.36×10^4
- B. 9.4×10^4
- C. 9.36×10^5
- D. 9.4×10^5

B

- 6 Cheryl was asked to write 80 000 in scientific notation to 2 s.f.

She wrote 8×10^5 .

- a Explain why this is incorrect.

This is only 1 significant figure

- b What should she have written?

8.0×10^5

- 7 Round the following to 3 s.f.

a 2.302×10^2

2.30×10^2

b 4.897×10^{-4}

4.90×10^{-4}

c 3.996×10^6

4.00×10^6

- 8 Calculate, give answer in scientific notation and round to four s.f.

a $10^{-0.4}$

3.981×10^{-1}

b
$$\frac{1}{240 - 13 \times 17}$$

5.263×10^{-2}

c $20000 \times (1.01)^{25}$

2.565×10^4

d
$$\frac{11.3}{\sqrt{19.5 - 14.7}}$$

5.158

e
$$\frac{3\frac{2}{3} + 5\frac{1}{4}}{4\frac{1}{2} + 6\frac{4}{5}}$$

7.891×10^{-1}

f $(87.3 \times 10^4) \div (0.629 \times 10^{-8})$

1.388×10^{14}

- 9 The mass of a proton is 1.6726×10^{-27} kg and the mass of an electron is 9.1095×10^{-31} kg.

- a Calculate, correct to 4 s.f., the ratio of the mass of the proton to the mass of an electron (i.e. how many times as heavy is a proton compared to an electron?)

1836 times as heavy

- b How many protons are there in 1 kg? Answer in scientific notation to 4 s.f.

5.979×10^{26}

CHECK YOUR UNDERSTANDING

Scientific notation

1	Which of these is NOT written in scientific notation (standard form)?						
a	1.03009×10^3	b	3.8×10^{-7}	c	5×10^{99}	d	0.7×10^4
2	Which is the correct way of writing 5 672 000 in standard form?						
a	5672×10^3	b	5.672×10^6	c	56.72×10^5	d	5.672×10^{-6}
3	Which is the correct way of writing 4.94×10^2 as an ordinary number in decimal form?						
a	494	b	49400	c	0.0494	d	4.94
4	Which is the correct way of writing 7.31×10^{-5} as an ordinary number in decimal form?						
a	0.000 073 1	b	7.31	c	-7.31	d	731 000
5	Which is the correct way of writing 0.00506 in scientific notation?						
a	5.06×10^3	b	5.6×10^{-3}	c	5.06×10^{-5}	d	5.06×10^{-3}
6	Choose the largest number.						
a	5.2×10^4	b	7.1×10^2	c	3.2456×10^2	d	6.708×10^{-3}
7	What should replace the star? $40 \times 10^6 = 4 \times 10 \star$						
a	5	b	6	c	7	d	60
8	What should replace the star? $0.4 \times 10^6 = 4 \times 10 \star$						
a	5	b	6	c	7	d	60