Using the addition law for indices

1 **a)** Fill in the gaps in the calculation.

$2^4 \times 2^3 = 2 \times 2 \times 2 \times 2 \times$ [2] $\times$ [2] $\times$ [2] $= 2^{[7]}$

b) What happens to the base value when 2^4 and 2^3 are multiplied?

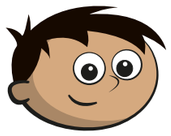
It stays the same.

c) What happens to the indices when 2^4 and 2^3 are multiplied?

You add them together.

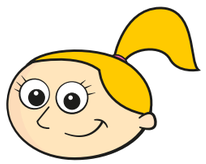
2 Amir and Eva are both trying a problem.

Simplify $3^{10} \times 3^{20}$



It is going to take a long time to answer this question because I have to write out the whole multiplication.

I can do it without writing out the multiplication.



What has Eva noticed?

3 Complete the statements.

a) $3^4 \times 3^5 = 3^{[9]}$

b) $4^2 \times 4^6 =$ [4^8]

c) $7^8 \times 7^{10} =$ [7^{18}]

d) $a^4 \times a^3 \equiv a^7$

e) $y^{11} \times y^6 \equiv y^{17}$

f) $p^4 \times p^7 \equiv p^{11}$

4 The addition rule for indices can be described using algebra.

Complete the statement.

The addition rule for indices is $x^a \times x^b \equiv x^{a+b}$

Describe the rule in your own words.

When multiplying, if the base is the same you can add the powers.

5 Simplify the expressions.

a) $x^3 \times x^4 \times x^5 \equiv x^{12}$

b) $v^7 \times v^7 \times v^7 \equiv v^{21}$

c) $h^3 \times h^8 \times h^{10} \equiv h^{21}$

d) $w^{50} \times w^{100} \times w^{250} \equiv w^{400}$

6 Identify and explain the mistake that has been made in each statement.

a) $3^2 \times 3^4 = 3^8$

Indices have been multiplied.

It should be $3^2 \times 3^4 = 3^6$

b) $5^2 \times 5^3 = 25^5$

Bases have been multiplied.

It should be $5^2 \times 5^3 = 5^5$

c) $10^4 + 10^5 = 10^9$

They are being added not multiplied.

$10^4 + 10^5$ can't be simplified.

d) $5^3 \times 2^6 = 7^9$

Bases have been added. The bases aren't the same so $5^3 \times 2^6$ can't be simplified.

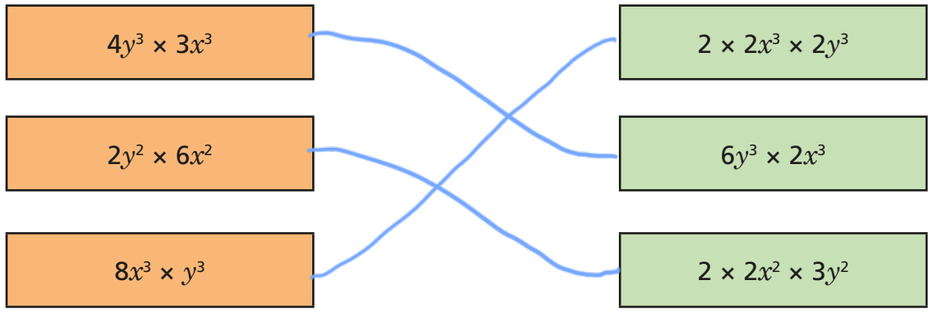
7 Simplify the expressions.

a) $a^3 \times b^2 \times a^4 \times b^5 \equiv a^{\boxed{7}} \times b^{\boxed{7}} \equiv$ a^7b^7

b) $m^4n^3 \times m^2n^3 \equiv$ m^6n^6

c) $p^2q^2 \times p^3r^3 \times q^4r^4 \equiv$ $p^5q^6r^7$

8 Match the equivalent expressions.



9 Fill in the missing powers and coefficients.

a) $2k^3 \times 4k^{\boxed{3}} \equiv \boxed{8}k^6$

b) $2m^2 \times 3m^{\boxed{10}} \times \boxed{5}m^4 \equiv 30m^{16}$

c) $3d^{\boxed{3}} \times \boxed{2}D^2 \times 2d^4 \times 3D^{\boxed{3}} \equiv 36d^7D^5$

10 Find the value of x.

a) $2^7 \times 2^x = 2^{12}$

$x =$ $\boxed{5}$

b) $3^x \times 3^x \times 3^4 = 3^{20}$

$x =$ $\boxed{8}$

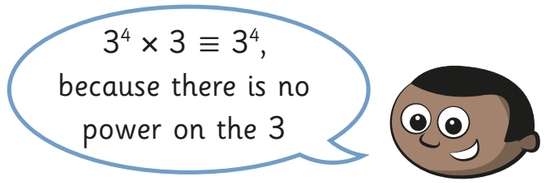
c) $d^x \times d^{x+1} = d^{11}$

$x =$ $\boxed{5}$

d) $5^{2x} \times 5^x \times 5^2 = 5^{23}$

$x =$ $\boxed{7}$

11



a) Write out the full multiplication to show why Mo is incorrect.

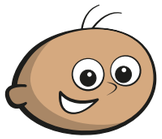
$3 \times 3 \times 3 \times 3 \times 3 \equiv 3^5$

b) Simplify the expressions.

$4^6 \times 4$	5×5^7	$a^3 \times a^2 \times a$	$3b^4 \times 4b$
4^7	5^8	a^6	$12b^5$

Using the addition and subtraction law for indices

1



2^8 divided by 2^5 is 2^3

a) Cancel the common factors in this division to show that Tommy is correct.

$$\frac{\cancel{2} \times \cancel{2} \times \cancel{2} \times \cancel{2} \times \cancel{2} \times 2 \times 2 \times 2}{\cancel{2} \times \cancel{2} \times \cancel{2} \times \cancel{2} \times \cancel{2}}$$

b)

$2^8 = 256$	$2^5 = 32$

Work out 256 divided by 32 [8]

Explain your method.

$2^3 = 2 \times 2 \times 2 = 8$

2 Complete the calculations by filling in the missing values.

a) $\frac{3^5}{3^3} = \frac{3 \times 3 \times 3 \times 3 \times 3}{3 \times 3 \times 3} = 3^{[2]}$

b) $\frac{5^6}{5^3} = \frac{5 \times 5 \times 5 \times 5 \times 5 \times 5}{5 \times 5 \times 5} = [5^3]$

c) $\frac{7^{10}}{7^4} = \frac{7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7 \times 7}{7 \times 7 \times 7 \times 7} = [7^6]$

3 Complete the expressions by filling in the missing values.

a) $\frac{k^5}{k^3} = \frac{k \times k \times k \times k \times k}{k \times k \times k} = k^{[2]}$

b) $\frac{m^6}{m^4} = \frac{m \times m \times m \times m \times m \times m}{m \times m \times m \times m} = m^2$

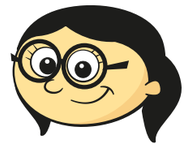
c) $\frac{t^{12}}{t^5} = \frac{t \times t \times t \times t \times t \times t \times t \times t \times t \times t \times t \times t}{t \times t \times t \times t \times t} = t^7$

What patterns do you notice?

The base stays the same and you subtract the powers.

4

The subtraction rule for indices can be described using algebra.



Complete the statement.

The subtraction rule for indices is $x^m \div x^n \equiv x^{m-n}$

Describe the rule in your own words.

When dividing, the base stays the same and you subtract the powers.

5 Simplify the expressions, giving each answer as a single term.

a) $2^{14} \div 2^6 =$ 2^8

b) $a^9 \div a^5 \equiv$ a^4

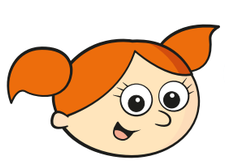
c) $t^6 \div t^2 \equiv$ t^4

d) $p^8 \div p^2 \equiv$ p^6

e) $y^8 \div y^4 \equiv$ y^4

f) $3k^7 \div k^4 \equiv$ $3k^3$

6 **a)**



$t^4 \div t = 4$ because the ts cancel out.

Discuss with a partner why Alex is wrong.

What is the correct answer? t^3

b) Simplify the expressions.

$2^7 \div 2 \equiv$ 2^6 $\quad a^9 \div a \equiv$ a^8 $\quad t^6 \div t \equiv$ t^5

7 Complete the statements.

a) $(4^3 \times 4^5) \div 4^2 = 4^{\boxed{8}} \div 4^2$

$= 4^{\boxed{6}}$

b) $(t^5 \times t^{10}) \div (t^6 \times t^7) \equiv t^{\boxed{15}} \div t^{\boxed{13}}$

$\equiv t^{\boxed{2}}$

c) $(m^8 \times m^4) \div (m^7 \times m^5) \equiv m^{\boxed{12}} \div m^{\boxed{12}}$

$\equiv m^{\boxed{0}}$

8 Fill in the correct operation for each statement.

a) 4^5 (×) $4^7 = 4^{12}$

b) 7^6 (÷) $7^4 = 7^2$

c) t^2 (×) $t^6 = t^{12}$ (÷) t^4

d) h^4 (÷) $h^3 = h^{10}$ (÷) h^9

9 Add brackets to make the statements true.

a) $9^8 \div (9^3 \times 9^2) = 9^3$

b) $6^5 \div (6^2 \times 6^3) \times 6^5 = 6^5$

c) $(a^4 \times a^7) \div (a^8 \times a^2) \equiv a$

d) $(f^{10} \div f^3) \div (f^{12} \div f^8) \equiv f^3$

10 Rearrange the cards to make a correct statement.

3^9 | × | 3^3 | ÷ | 3^5 | = | 3^7

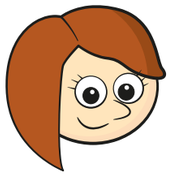
3^5 $\quad 3^3$ $\quad 3^9$ $\quad 3^7$

× $\quad$ = $\quad$ ÷

Compare answers with a partner.

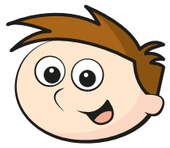
11 Rosie and Teddy are looking at the same question.

Work out $5^2 \div 5^2$



Rosie: I think the answer is 1, because if you divide a number by itself you always get the number 1

Teddy: I think the answer is 5^0, because when you use the subtraction rule for indices, you subtract the powers.



Who is correct? Circle your answer.

Teddy $\quad$ Rosie $\quad$ (both) $\quad$ neither

Explain your answer.

Work with numbers greater than 1 in standard form

1 Complete the statements.

a) 30,000 = 3 × [10,000] = 3 × 10^4

b) 600,000 = 6 × [100,000] = 6 × 10[5]

c) 700 = 7 × [100] = [7] × 10[2]

d) 8,000,000 = [8] × [1,000,000] = [8] × 10[6]

e) three hundred thousand = [3] × [100,000] = [3] × 10[5]

f) four billion = [4] × [1,000,000,000] = [4] × 10[9]

g) twenty million = [2] × [10,000,000] = [2] × 10[7]

2 Tick the numbers that are **not** in standard index form.

50×10^7 ✓	$5 \times 10^{\frac{3}{4}}$ ✓	0.5×10^3 ✓	5×10^6
$\frac{3}{4} \times 10^5$ ✓	6×10^{72}	$9 \times 10^{1.5}$ ✓	1×10^1

3 Write >, < or = to complete the statements.

a) 10,000 < 10^5

b) 400,000 > 8×10^4

c) 6×10^2 = 600

d) 20,000 = 2×10^4

e) 3×10^7 > 3,700,000

4 Write the standard form numbers as ordinary numbers.

a) 9×10^5 = 900,000

b) 8×10^7 = 80,000,000

c) 4×10^8 = 400,000,000

d) 6×10^3 = 6,000

e) 7×10^2 = 700

f) 10^6 = 1,000,000

5 Fill in the missing information.

a) 60,000 = 6 × 10,000 = 6 × 10^4

b) 70,000 = 7 × 10,000 = [7] × 10^4

c) 65,000 = 6.5 × 10,000 = [6·5] × 10^4

d) 63,000 = [6·3] × 10,000 = [6·3] × 10^4

e) 780,000 = [7·8] × 100,000 = [7·8] × 10^5

f) 9900 = [9·9] × [1,000] = [9·9] × 10[3]

g) 680,000 = [6·8] × [100,000] = [6·8] × 10[5]

h) 834,000,000 = [8·34] × [100,000,000] = [8·34] × 10[8]

6 Write the numbers in standard index form.

a) 50,000 = 5×10^4

b) 53,000 = $5 \cdot 3 \times 10^4$

c) 53,200 = $5 \cdot 32 \times 10^4$

d) 500,000 = 5×10^5

e) 520,000 = $5 \cdot 2 \times 10^5$

f) 502,000 = $5 \cdot 02 \times 10^5$

7 Write the standard form numbers as ordinary numbers.

a) $4 \times 10^5 =$ 400,000

b) $4.1 \times 10^5 =$ 410,000

c) $4.01 \times 10^5 =$ 401,000

d) $4.001 \times 10^5 =$ 400,100

e) $6.1 \times 10^3 =$ 6,100

f) $6.1 \times 10^4 =$ 61,000

g) $6.1 \times 10^5 =$ 610,000

h) $1.6 \times 10^5 =$ 160,000

8 **a)** The planet Mercury is on average 58 million km from the Sun.

Write this distance in standard form.

5.8×10^7 km

b) The planet Neptune is on average 4.5×10^9 km from the Sun.

Write this distance as an ordinary number.

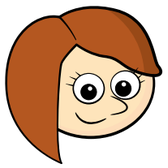
4,500,000,000 km

c) The number of bacteria in the average human body is estimated to be 39,000,000,000,000

Write this number in standard form.

3.9×10^{13}

9 **a)**



9 is greater than 2, so 9×10^5 is greater than 2×10^6

Do you agree with Rosie? No

Explain why.

b) Write the numbers in ascending order.

4 billion	4×10^7	410,000,000	4.2×10^5	401 million

4.2×10^5, 4×10^7, 401 million, 410,000,000, 4 billion

8×10^{10}	8 billion	800 million	8.8×10^7	800,000,000,000

8.8×10^7, 800 million, 8 billion, 8×10^{10}, 800,000,000,000

10

50×10^5 is not in standard form.
$50 \times 10^5 = 5 \times 10^1 \times 10^5 = 5 \times 10^6$
Now the number is in standard form.

Use Whitney's reasoning to write the numbers in standard form.

a) $30 \times 10^4 =$ 3×10^5

b) $200 \times 10^5 =$ 2×10^7

c) $230 \times 10^5 =$ 2.3×10^7

d) $10 \times 7 \times 10^4 =$ 7×10^5

e) $8{,}000 \times 10^1 =$ 8×10^4

f) $91.7 \times 10^4 =$ 9.17×10^5

Work with numbers between 0 and 1 in standard form

1 Complete the statements.

a) $0.007 = 7 \times$ [0.001] $= 7 \times 10^{-3}$

b) $0.06 = 6 \times$ [0.01] $= 6 \times 10^{}$ [-2]

c) $0.0008 = 8 \times$ [0.0001] $=$ [8] $\times 10^{}$ [-4]

d) $0.0000004 =$ [4] $\times$ [0.0000001] $=$ [4] $\times 10^{}$ [-7]

e) $\frac{7}{10000} =$ [7] $\times$ [0.0001] $=$ [7] $\times 10^{}$ [-4]

f) three thousandths = [3] $\times$ [0.001] $=$ [3] $\times 10^{}$ [-3]

g) 2 millionths = [2] $\times$ [0.000001] $=$ [2] $\times 10^{}$ [-6]

2 Tick the numbers that are **not** in standard index form.

4×10^{-27}	$6 \times 10^{-\frac{3}{4}}$ ✓	0.05×10^{-2} ✓	5.4×10^{-6}
7×10^{5}	$1.6 \times 10^{-0.4}$ ✓	$10 \times 10^{-1.5}$ ✓	10×10^{-1} ✓

3 Write >, < or = to complete the statements.

a) 0.0001 [=] 10^{-4}

b) 0.004 [<] 3×10^{-2}

c) 8×10^{-2} [<] 0.9

d) $\frac{1}{2}$ [=] 5×10^{-1}

e) 3×10^{-5} [=] $\frac{3}{100000}$

4 Write the standard form numbers as ordinary numbers.

a) $6 \times 10^{-3} =$ [0.006]

b) $7 \times 10^{-4} =$ [0.0007]

c) $8 \times 10^{-5} =$ [0.00008]

d) $5 \times 10^{-2} =$ [0.05]

e) $8 \times 10^{-6} =$ [0.000008]

f) $10^{-1} =$ [0.1]

5 Fill in the missing information.

a) $0.008 = 8 \times 0.001 = 8 \times 10^{-3}$

b) $0.009 = 9 \times 0.001 =$ [9] $\times 10^{-3}$

c) $0.0085 = 8.5 \times 0.001 =$ [8.5] $\times 10^{-3}$

d) $0.0083 =$ [8.3] $\times 0.001 =$ [8.3] $\times 10^{-3}$

e) $0.027 =$ [2.7] $\times 0.01 =$ [2.7] $\times 10^{-2}$

f) $0.000062 =$ [6.2] $\times$ [0.00001] $=$ [6.2] $\times 10^{}$ [-5]

g) $0.67 =$ [6.7] $\times$ [0.1] $=$ [6.7] $\times 10^{}$ [-1]

h) $0.00000056 =$ [5.6] $\times$ [0.0000001] $=$ [5.6] $\times 10^{}$ [-7]

6 Write the ordinary numbers in standard index form.

a) $0.0004 =$ [4×10^{-4}]

b) $0.00043 =$ [4.3×10^{-4}]

c) $0.000437 =$ [4.37×10^{-4}]

d) $0.002 =$ [2×10^{-3}]

e) $0.0021 =$ [2.1×10^{-3}]

f) $0.00201 =$ [2.01×10^{-3}]

7 Write the standard form numbers as ordinary numbers.

a) 3×10^{-3} = 0·003

b) 3.1×10^{-3} = 0·0031

c) 3.81×10^{-3} = 0·00381

d) 8.27×10^{-4} = 0·000827

e) 8.27×10^{-5} = 0·0000827

f) 8.207×10^{-5} = 0·00008207

8 **a)** The length of a plant cell is about 0.00005 m.

Write this length in standard form.

5×10^{-5} m

b) A blood cell is about 8×10^{-6} m long.

Write this length as an ordinary number.

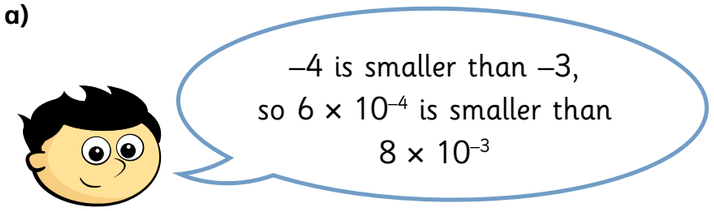
0·000008 m

c) The diameter of a proton is about 0.00000000000000087 m.

Write this length in standard form.

8.7×10^{-16} m

9 **a)**



Do you agree with Jack? Yes

Explain your answer.

$6 \times 10^{-4} = 0.0006$ $8 \times 10^{-3} = 0.008$

$0.0006 < 0.008$

b) Write the numbers in ascending order.

7 hundredths	7×10^{-7}	0.007	7.5×10^{-2}	0.017

7×10^{-7}, 0·007, 0·017, 7 hundredths, 7.5×10^{-2}

6×10^{-7}	$\frac{6}{100000}$	0.000000667	6.6×10^{-6}	6 millionths

6×10^{-7}, 0·000000667, 6 millionths, 6.6×10^{-6}, $\frac{6}{100000}$

10

0.3×10^{-4} is not in standard form.
$0.3 \times 10^{-4} = 3 \times 10^{-1} \times 10^{-4} = 3 \times 10^{-5}$
Now the number is in standard form.

Use Mo's reasoning to write these numbers in standard form.

a) 0.7×10^{-4} = 7×10^{-5}

70×10^{-4} = 7×10^{-3}

0.07×10^{-4} = 7×10^{-6}

b) 0.6×10^{-3} = 6×10^{-4}

0.06×10^{-3} = 6×10^{-5}

600×10^{-3} = 6×10^{-1}

c) 53.8×10^{-4} = 5.38×10^{-3}

538×10^{-4} = 5.38×10^{-2}

0.0538×10^{-4} = 5.38×10^{-6}