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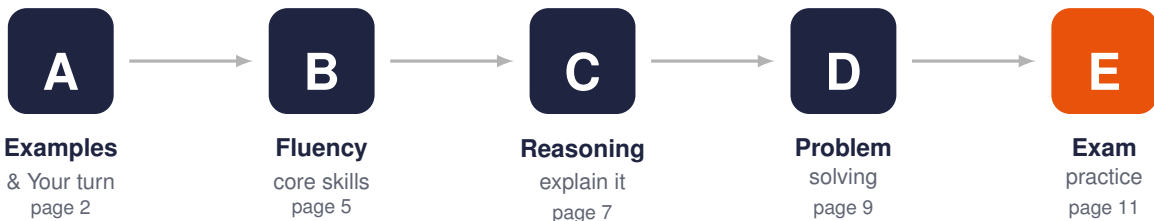
GCSE MATHEMATICS • NUMBER

Indices

Worksheet

Pearson Edexcel GCSE (1MA1) & International GCSE (4MA1) • No calculator

Free Indices worksheet for GCSE and iGCSE Maths, with full worked solutions



Tap a section to jump straight to it

By the end of this worksheet you can: use index notation and the laws of indices • understand zero and negative indices • apply the laws to algebra • *Higher:* evaluate fractional indices, solve equations by writing both sides as powers of the same base, and express powers in terms of each other.

Which questions are for me?

FOUNDATION Everyone starts here. These skills appear on both tiers.

HIGHER Fractional indices, which are Higher-only content, then equations with powers and expressing one power in terms of another.

Every section has both, clearly labelled. Questions get harder as you go, and every skill in Sections A to D is needed in Section E.

Track your progress

Section	B	C	D	E
Foundation marks	24	11	15	13
Higher marks	20	15	18	18
My score				

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A

Worked examples & Your turn

Read each example carefully. Cover it up, then answer the question beside it using the same method.

FOUNDATION

Everyone starts here

Worked example A1: multiplying and dividing powers

Write as a single power (a) $5^4 \times 5^3$ (b) $7^9 \div 7^4$

Same base. When multiplying, **add** the indices.

(a) $5^{4+3} = 5^7$

When dividing, **subtract** the indices.

(b) $7^{9-4} = 7^5$

(a) 5^7 (b) 7^5

Your turn A1

Write as a single power (a) $3^5 \times 3^6$
(b) $2^{10} \div 2^3$

Worked example A2: a power of a power

Work out the value of $\frac{(4^3)^2 \times 4}{4^5}$

Power of a power: **multiply** the indices. Remember $4 = 4^1$

Top: $4^6 \times 4^1 = 4^7$

Divide by subtracting, then work out the value.

$4^{7-5} = 4^2 = 16$

16

Your turn A2

Work out the value of $\frac{(2^4)^3}{2^5 \times 2^4}$

Worked example A3: zero and negative indices

Work out (a) 6^0 (b) 2^{-3} (c) $\left(\frac{2}{3}\right)^{-2}$

Anything (except 0) to the power 0 is 1.

A negative index means "one over". For a fraction, flip it.

(b) $2^{-3} = \frac{1}{2^3} = \frac{1}{8}$ (c) $\left(\frac{3}{2}\right)^2 = \frac{9}{4}$

(a) 1 (b) $\frac{1}{8}$ (c) $\frac{9}{4}$

Your turn A3

Work out (a) 9^0 (b) 5^{-2} (c) $\left(\frac{3}{4}\right)^{-2}$



Worked example A4: the laws in algebraSimplify (a) $3a^2 \times 4a^5$ (b) $(2x^3)^4$ *Multiply the numbers. Add the indices.*

(a) $3 \times 4 = 12$ and $a^{2+5} = a^7$

*The power outside applies to the number **and** to the letter.*

(b) $2^4 = 16$ and $x^{3 \times 4} = x^{12}$

(a) $12a^7$ (b) $16x^{12}$

Your turn A4Simplify (a) $5b^3 \times 2b^4$ (b) $(3y^2)^3$ **HIGHER***Higher only: fractional indices***Worked example A5: a fractional index**Work out $16^{\frac{3}{4}}$ *The bottom of the fraction is the **root**. The top is the **power**. Do the root first so the numbers stay small.*

$$\sqrt[4]{16} = 2$$

Then the power.

$$2^3 = 8$$

$$8$$

Your turn A5Work out $125^{\frac{2}{3}}$ **Worked example A6: a negative fractional index**Work out $\left(\frac{25}{9}\right)^{-\frac{3}{2}}$ *Deal with the negative first: flip the fraction.*

$$\left(\frac{9}{25}\right)^{\frac{3}{2}}$$

Square root top and bottom, then cube.

$$\left(\frac{3}{5}\right)^3 = \frac{27}{125}$$

$$\frac{27}{125}$$

Your turn A6Work out $\left(\frac{16}{81}\right)^{-\frac{3}{4}}$ 

HIGHER*Higher strategies: these are new ways of thinking, not longer sums***Worked example A7: writing both sides with the same base**

Solve $9^x = 27$

9 and 27 are both powers of 3.

$$(3^2)^x = 3^3 \quad \text{so} \quad 3^{2x} = 3^3$$

The bases match, so the indices must be equal.

$$2x = 3$$

$$x = \frac{3}{2}$$

Your turn A7

Solve $8^x = 32$

Worked example A8: expressing one power in terms of another

$$x = 3^p$$

Write in terms of x **(a)** 3^{p+2} **(b)** 9^p

Split the index using the laws backwards.

(a) $3^{p+2} = 3^p \times 3^2 = 9x$

Change the base so that 3^p appears.

(b) $9^p = (3^2)^p = (3^p)^2 = x^2$

(a) $9x$ **(b)** x^2

Your turn A8

$$y = 5^q$$

Write in terms of y **(a)** 5^{q-1} **(b)** 25^q



B**Fluency**

Each question is a designed sequence. From one part to the next, ask yourself: what changed, and what did it do to the answer? No calculator.

FOUNDATION*Everyone starts here***B1** Work out

(a) 2^4

(b) 4^2

(c) $(-2)^4$

(d) -2^4

[4 marks]**B2** Write as a single power of the base shown in bold.

(a) $3^2 \times 3^5$ (**3**)

(b) $3^2 \times 3$ (**3**)

(c) $3^2 \times 3^{-5}$ (**3**)

(d) $4^2 \times 2^3$ (**2**)

[4 marks]**B3** Write as a single power of 7

(a) $7^8 \div 7^2$

(b) $7^2 \div 7^8$

(c) $7^5 \div 7^5$

(d) $7^3 \div 7^{-2}$

[4 marks]**B4** Write as a single power of 5, or as a number.

(a) $(5^2)^3$

(b) $(5^3)^2$

(c) $(5^{-1})^4$

(d) $(5^2)^0$

[4 marks]**B5** Work out

(a) 8^0

(b) 4^{-1}

(c) 10^{-3}

(d) $\left(\frac{1}{2}\right)^{-3}$

[4 marks]**B6** Simplify

(a) $a^3 \times a^4$

(b) $6m^5 \div 2m^2$

(c) $(p^2q)^3$

(d) $4x^{-2} \times 3x^5$

[4 marks]

HIGHER*Higher only: fractional indices***B7** Work out

(a) $49^{\frac{1}{2}}$

(b) $1000^{\frac{1}{3}}$

(c) $81^{\frac{1}{4}}$

(d) $\left(\frac{1}{36}\right)^{\frac{1}{2}}$

[4 marks]**B8** Work out

(a) $9^{\frac{3}{2}}$

(b) $32^{\frac{2}{5}}$

(c) $100^{\frac{3}{2}}$

(d) $8^{\frac{4}{3}}$

[4 marks]**B9** Work out

(a) $25^{-\frac{1}{2}}$

(b) $27^{-\frac{1}{3}}$

(c) $16^{-\frac{3}{2}}$

(d) $\left(\frac{4}{9}\right)^{-\frac{1}{2}}$

[4 marks]**B10** Solve

(a) $2^x = 32$

(b) $3^x = \frac{1}{9}$

(c) $25^x = 5$

(d) $4^x = \frac{1}{8}$

[4 marks]**B11** Simplify

(a) $(16x^4)^{\frac{1}{2}}$

(b) $(27y^6)^{\frac{2}{3}}$

(c) $\left(x^{\frac{1}{2}}\right)^4$

(d) $x^{\frac{3}{2}} \div x^{\frac{1}{2}}$

[4 marks]

C**Reasoning**

Show your working and explain your thinking. A correct answer without a reason does not score full marks.

FOUNDATION

Everyone starts here

- C1** Tia says, " $2^3 = 6$ "
Explain the mistake Tia has made, and write down the correct value. [2 marks]
- C2** Use the fact that $5^3 \div 5^3 = 1$ to explain why $5^0 = 1$ [2 marks]
- C3** Is $3^2 \times 3^3$ equal to 9^5 ?
You **must** show your working. [2 marks]
- C4** Which is greater, 2^{-3} or 3^{-2} ?
You **must** show your working. [2 marks]
- C5** (a) Write 8×4^2 as a single power of 2 (b) Write $\frac{1}{16}$ as a power of 2 [3 marks]



HIGHER*Higher tier only*

C6 Jay says, " $16^{\frac{3}{2}} = 16 \times \frac{3}{2} = 24$ "

Explain Jay's mistake, and work out the correct value.

[2 marks]

C7 Write these in order of size. Start with the smallest.

$$4^{\frac{1}{2}} \quad 4^{-1} \quad 4^0 \quad 4^{-\frac{1}{2}} \quad 4^{\frac{3}{2}}$$

[3 marks]

C8 $5^{-n} = 0.4$

Work out the value of $(5^n)^2$

[3 marks]

C9 $\sqrt[3]{5} \times 25 = 5^n$

Find the value of n .

[3 marks]

C10 (a) Show that $2^{n+1} + 2^n = 3 \times 2^n$

(b) Hence write $2^{12} + 2^{10}$ as a product of its prime factors.

[4 marks]



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D**Problem solving**

You decide the method. Read the whole question first, and show every step.

FOUNDATION

Everyone starts here

- D1** A scientist starts with 1 cell. The number of cells doubles every hour.
(a) Write the number of cells after 6 hours as a power of 2, and work out its value.
(b) After how many hours are there first more than 1000 cells? [3 marks]
- D2** (a) A square has sides of length 3^4 cm. Write its area as a power of 3
(b) A rectangle measures 2^5 cm by 2^3 cm. Work out its area as an ordinary number. [3 marks]
- D3** 1 kilobyte is 2^{10} bytes. 1 megabyte is 2^{10} kilobytes.
How many bytes are there in 8 megabytes? Give your answer as a power of 2 [3 marks]
- D4** Find the value of x in each case.
(a) $5^x \times 5^4 = 5^{10}$ (b) $(2^x)^3 = 2^{12}$ (c) $3^7 \div 3^x = 3^{-2}$ [3 marks]
- D5** Work out the value of $\frac{6^2 \times 6^{-5}}{6^{-1}}$
Give your answer as a fraction. [3 marks]



HIGHER*Higher tier only***D6** A square has an area of 2^7 cm^2 .Work out the length of one side. Give your answer in the form $a\sqrt{2}$ **[3 marks]****D7** $a = 7^m$ and $b = 7^n$ Write each of these in terms of a and/or b .

(a) 7^{m+n}

(b) 49^m

(c) 7^{n-1}

(d) 7^{2m-n}

[4 marks]**D8** $2^x \times 4^y = 32$ and $3^x \div 3^y = 9$ Find the value of x and the value of y .**[4 marks]****D9** Solve $9^{x+1} = 27^x$ **[3 marks]****D10** $2^x = 5$ Without finding x , work out the value of

(a) 2^{x+3}

(b) 4^x

(c) 8^{-x}

[4 marks]

E**Exam practice**

Exam-style questions. Write your answers in the spaces. Aim for about one minute per mark. No calculator.

FOUNDATION*Foundation and Higher crossover***E1** (a) Work out the value of 3^4

.....
(1)

(b) Write $5^6 \times 5^2$ as a single power of 5

.....
(1)

(c) Write $9^7 \div 9^3$ as a single power of 9

.....
(1)

(d) Write $(2^3)^5$ as a single power of 2

.....
(1)

(Total for Question E1 is 4 marks)

E2 (a) Write down the value of 7^0

.....
(1)

(b) Work out the value of 2^{-4}

.....
(1)

(c) Work out the value of $\frac{3^4 \times 3^5}{3^7}$

.....
(2)

(Total for Question E2 is 4 marks)



E3 Simplify

(a) $m^4 \times m^5$

.....
(1)

(b) $12k^8 \div 3k^2$

.....
(2)

(c) $(2w^3)^4$

.....
(2)

(Total for Question E3 is 5 marks)

HIGHER*Higher tier only***E4** Work out the value of

(a) $121^{\frac{1}{2}}$

.....
(1)

(b) $216^{-\frac{2}{3}}$

.....
(2)

(c) $\left(\frac{8}{27}\right)^{\frac{4}{3}}$

.....
(2)

(Total for Question E4 is 5 marks)



E5 (a) $3^n = \frac{1}{81}$ Find the value of n .

$$n = \dots\dots\dots$$

(1)

(b) $9^n = 243$ Find the value of n .

$$n = \dots\dots\dots$$

(2)

(Total for Question E5 is 3 marks)

E6 Simplify fully $\frac{(5a^3b^2)^2}{a^{-2}b}$

.....

(Total for Question E6 is 3 marks)

E7 Solve $2^{3x-1} = 4^{x+2}$

$$x = \dots\dots\dots$$

(Total for Question E7 is 3 marks)



E8 Show that $\frac{2^{n+2} + 2^n}{2^{n+1} - 2^n} = 5$ for all values of n .

(Total for Question E8 is 4 marks)

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