MATHS FIELD GUIDE · GRADE 9

Integer powers and standard form

OPENING PROBLEM

Why add the exponents?

$$2^3 \times 2^2$$
$$\downarrow$$
$$(2 \times 2 \times 2) \times (2 \times 2)$$
$$\downarrow$$
$$2^5 = 32$$

02 Count the factors before using a power rule
03 Rules and worked cases
04 From the givens to the answer
05 Move between tenths, money and measurement
06 Check your reasoning
07 Check your reasoning

ILLUSTRATED PROBLEM SHEET

Count the factors before using a power rule

Multiplying equal bases joins factor lists. Dividing cancels matching factors when the base is nonzero.

1

$$2^3 \times 2^2$$
$$\downarrow$$
$$(2 \times 2 \times 2) \times (2 \times 2)$$
$$\downarrow$$
$$2^5 = 32$$

Why add the exponents?

All five factors have the same base.

2

$$3^4 \div 3^2$$
$$\downarrow$$
$$(3 \times 3 \times 3 \times 3) \div 9$$
$$\downarrow$$
$$3^2 = 9$$

Why subtract the exponents?

Two numerator factors cancel with two denominator factors.

3

$$5^0 = 5^3 \div 5^3$$
$$\downarrow$$
$$125 \div 125$$
$$\downarrow$$
$$1$$

What condition matters for a zero exponent?

Use a nonzero base so that the division exists.

4

$$0.0048$$
$$\downarrow$$
$$4.8 \times 10^{-3}$$
$$\downarrow$$
$$4.8 \div 1000$$

How does the minus sign change the scale?

It selects the reciprocal power of ten. The number itself stays positive.

$10^{-2} \times 10^5$
10^3.

$10^{-2} \div 10^5$
10^{-7}.

CHAPTER PROBLEM

Evaluate 2^{-3}. Enter a fraction.

1/8. $2^{-3} = 1/2^3 = 1/8$.

MATHS REFERENCE · GRADE 9

Integer powers and standard form

Rules, conditions and worked cases

Recognise the case	Mathematical reasoning
Negative exponent	$2^{-3} = 1/2^3 = 1/8$; the base must be nonzero.
Standard form	$0.00072 = 7.2 \times 10^{-4}$. The leading factor is at least 1 and less than 10.
Multiply in standard form	$(3 \times 10^4)(4 \times 10^{-2}) = 12 \times 10^2 = 1.2 \times 10^3$.

Read the representations

A power counts repeated factors

For a positive integer n, a^n means n factors of a multiplied together.

With the same non-zero base, $a^m \times a^n = a^{m+n}$ and $a^m / a^n = a^{m-n}$.

The quotient rule requires $a \neq 0$ because division by zero is undefined.

Divide by 3 at each downward step

Position or power	Value
3^3	27
3^2	9
3^1	3
3^0	1
3^{-1}	1/3
3^{-2}	1/9

Each downward step divides by the base. The pattern explains zero and negative powers.

Zero and negative exponents follow the same pattern

For $a \neq 0$, $a^0 = 1$ because $a^n / a^n = 1$.

A negative exponent means a reciprocal: $a^{-n} = 1/a^n$ for positive integer n.

It does not mean a negative value. Here 0^0 and negative powers of zero are left undefined.

Standard form separates scale and size

Write a non-zero number as $A \times 10^n$, where $1 \leq |A| < 10$ and n is an integer.

For positive numbers, $45000 = 4.5 \times 10^4$ and $0.0062 = 6.2 \times 10^{-3}$.

A positive exponent describes a large power of ten; a negative exponent describes a reciprocal power.

$$45000 = 4.5 \times 10000$$
$$= 4.5 \times 10^4$$

$$0.0062 = 6.2 / 1000$$
$$= 6.2 \times 10^{-3}$$

Changing the decimal coefficient must be balanced by changing the power of ten.

2 6 18 54 ?

What single multiplier fits every step?

Multiply by three. The next term is 162.

WORKED EXAMPLES

From the givens to the answer

Does 5^{-2} equal -25?

A learner changes a negative exponent into a negative sign.

1. The exponent controls repeated multiplication or its reciprocal.
2. $5^{-2} = 1/5^2 = 1/25$.
3. The base is positive, so this value is positive.

Calculate $(3 \times 10^4)(2 \times 10^3)$

1. Multiply the coefficients: $3 \times 2 = 6$.
2. Multiply the powers of ten: $10^4 \times 10^3 = 10^7$.
3. The result is 6×10^7. The coefficient already lies between 1 and 10.

Write 0.00084 in standard form

1. Choose coefficient 8.4.
2. 8.4 must be divided by 10000 to recover the original number, so the power is 10^{-4}.
3. Thus $0.00084 = 8.4 \times 10^{-4}$. Check the magnitude: it is less than 1.

Check another case

Example 1

Explain why 0^{-1} is undefined.

The negative exponent would require 1/0.

Division by zero is undefined.

Thus the reciprocal rule cannot be applied with base zero.

Example 2

Evaluate 10^{-2}.

1/100

$10^{-2} = 1/10^2$.

Stage	0	1	2	3
Pieces	1	3	9	27

If each piece makes three copies, how many after stage four?

81. Four multiplications carry the initial piece to stage four.

ILLUSTRATED PROBLEM SHEET

Move between tenths, money and measurement

Scale both quantities in a division by the same nonzero factor. In multiplication, track each factor's place value.

1

$$0.3 \times 0.4$$
$$\downarrow$$
$$3 \text{ tenths} \times 4 \text{ tenths}$$
$$\downarrow$$
$$12 \text{ hundredths} = 0.12$$

Which unit does each small product represent?

A tenth of a tenth is a hundredth. Twelve such pieces give 0.12.

2

$$2.4 \div 0.3$$
$$\downarrow$$
$$24 \text{ tenths} \div 3 \text{ tenths}$$
$$\downarrow$$
$$8 \text{ groups}$$

Why can the quotient exceed 2.4?

It counts groups that are smaller than one whole unit.

3

$$4.8 \div 6$$
$$\downarrow$$
$$48 \text{ tenths} \div 6$$
$$\downarrow$$
$$8 \text{ tenths} = 0.8$$

What does eight count in the second line?

Eight tenths per group. Write the decimal unit back into the answer.

4

Change	Start	Result
× 10	0.045	0.45
÷ 10	0.45	0.045

Does the digit 4 change its value?

Yes. Multiplying by ten moves its value from four hundredths to four tenths.

0.05×0.2
0.01.

$0.05 \div 0.2$
0.25.

CHAPTER PROBLEM

Evaluate 7^0.

1. Any non-zero base to power zero is 1.

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Check your reasoning

Try the problem	Solution and reasoning
01 Is $2^3 + 2^2$ equal to 2^5?	No. Addition combines the values 8 and 4 to give 12. The product rule applies to multiplication.
02 Which is standard form for 720000? A) 72×10^4 B) 7.2×10^5 C) 0.72×10^6 D) 7.2×10^{-5}	7.2×10^5 The coefficient is between 1 and 10 and $7.2 \times 100000 = 720000$.
03 Can 0.7×0.8 equal 5.6?	No. Both positive factors are below one. The product is 56 hundredths, or 0.56.
04 Evaluate 4^{-2}.	$1/16$ $4^{-2} = 1/16$.
05 Which restriction is needed for x^{-3}? A) $x > 1$ B) $x \neq 0$ C) x is negative D) No restriction	$x \neq 0$ $x^{-3} = 1/x^3$ requires a non-zero denominator.
06 Find the exponent n in $32000 = 3.2 \times 10^n$.	4 $3.2 \times 10000 = 32000$, so n = 4.

Which is bigger after conversion?

Compare 7.2×10^{-3} and 8×10^{-4} by expressing both in ten-thousandths. The first has 72 of them and the second has eight.

The first number is nine times the second. The leading digit alone would suggest the wrong order.

$$2 \rightarrow -6 \rightarrow 18$$
$$\downarrow$$
$$r = -3$$

Does a negative ratio prevent growth in size?

No. Signs alternate while the magnitudes triple.

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Check your reasoning

Try the problem	Solution and reasoning
07 Which equals 0.00056? A) 5.6×10^{4} B) 5.6×10^{-4} C) 56×10^{-4} D) 5.6×10^{-3}	5.6×10^{-4} 5.6/10000 = 0.00056.
08 Simplify $2^{6} / 2^{2}$ and enter its value.	16 $2^{6} / 2^{2} = 2^{4} = 16$.
09 Explain why a negative exponent does not by itself make a number negative.	It indicates the reciprocal of a positive power. For example $3^{-2} = 1/9$, which is positive. The sign depends on the base and the integer power, not an extra minus sign from the exponent.
10 Explain why 48×10^{3} equals 4.8×10^{4} but only the second is in standard form.	The coefficient decreases by a factor 10. The power of ten increases by a factor 10, preserving the product. Only 4.8 satisfies the required coefficient range.
11 Which is a valid standard-form representation? A) 63×10^{5} B) 0.63×10^{7} C) 6.3×10^{6} D) 630×10^{4}	6.3×10^{6} Only 6.3 has magnitude at least 1 and less than 10.

Stage	0	1	2
Squares	1	8	64
Area left	1	8/9	64/81

Remove the middle ninth from every surviving square. What grows and what shrinks?

The count grows eightfold while total remaining area is multiplied by 8/9 each round.

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