GCSE MATHEMATICS

HIGHER TIER

COMPREHENSIVE LESSON NOTEBOOK

UNIT 1 | NUMBER

TEACH-FROM-SCRATCH • FREE WEBSITE EDITION

16 detailed chapters • original diagrams • worked examples • guided practice • answers

Student: ________________________________ Target grade: _____

START HERE

STUDY ROUTINE

How to learn from this notebook

Meaning first. Method second. Practice third.

THE FIVE-PASS ROUTINE

1 Read the key idea without a calculator. 2 Cover each solution and reproduce it. 3 Complete the practice independently. 4 Mark in a different colour and repair errors. 5 Retest after 2–7 days.

What a complete mathematics answer contains

- A clear model or calculation, not only a calculator display.
- Enough working for another person to follow the reasoning.
- Exact values until approximation is requested.
- Units and sensible rounding in context.
- A final sentence when the result must be interpreted.

Error log

REPAIR, DO NOT MERELY CORRECT

Label each error: concept, operation, arithmetic, calculator entry, accuracy, unit or interpretation. Write the corrected step and one sentence explaining the change.

Higher Tier requires connected depth

Higher Tier rewards secure fluency and connected reasoning. Grade 4–5 questions often combine several familiar skills, hide the required operation inside a context, or ask whether an answer is reasonable. The notebook therefore explains why methods work as well as how to use them.

SPECIFICATION MAP

PEARSON EDEXCEL 1MA1

Unit 1 coverage map

Number content organised into a teachable sequence.

CH 01	N1, N2	Ordering real numbers and directed calculation
CH 02	N2, N3	Operation structure, reciprocals and exact arithmetic
CH 03	N4	Prime structure, HCF, LCM and divisibility proof
CH 04	N5	Systematic listing and the product rule for counting
CH 05	N6, N7	Integer indices, roots and estimating powers
CH 06	N7	Fractional indices and inverse powers
CH 07	N8	Surds and exact radical arithmetic
CH 08	N8	Rationalising denominators and conjugates
CH 09	N2, N8, N10, N11, N12	Fraction structure, operators and exact proportional reasoning
CH 10	N10	Recurring decimals as exact fractions
CH 11	N9	Standard form across multiple operations
CH 12	N12; linked R9, R16	Percentage operators, reverse percentages and repeated change
CH 13	N13	Unit systems and compound-measure conversion
CH 14	N14, N15	Estimation, significant figures and numerical error
CH 15	N15, N16	Bounds and limits of accuracy in multi-step calculations
CH 16	N1-N16 synthesis	Higher Number modelling, proof and multi-stage reasoning

IMPORTANT TIER NOTE

This notebook follows the complete Higher Tier Number content identified in the Pearson Edexcel GCSE Mathematics (1MA1) specification, including shared foundations and Higher-only extensions.

REFERENCE

NUMBER FACTS AND FORMULAS

Fast-reference method bank

Understand each formula before memorising it.

Index multiplication	$a^m a^n = a^{m+n}$
Fractional index	$a^{m/n} = (\sqrt[n]{a})^m$
Negative index	$a^{-n} = 1/a^n$
Surd conjugates	$(a+b\sqrt{c})(a-b\sqrt{c}) = a^2 - b^2c$
Standard form	$A \times 10^n$, $1 \le \lvert A \rvert < 10$
Compound growth	$\text{original} \times \text{multiplier}^n$
Error interval	rounded value ± half-unit
Upper positive quotient	numerator upper ÷ denominator lower
Percentage error	absolute error÷accepted value×100%
Product rule	multiply choices at successive stages

CHAPTER 01 • N1-N2

N1, N2

Ordering real numbers and directed calculation

Compare exact forms intelligently and control signs through multi-step arithmetic.

SPECIFICATION FOCUS

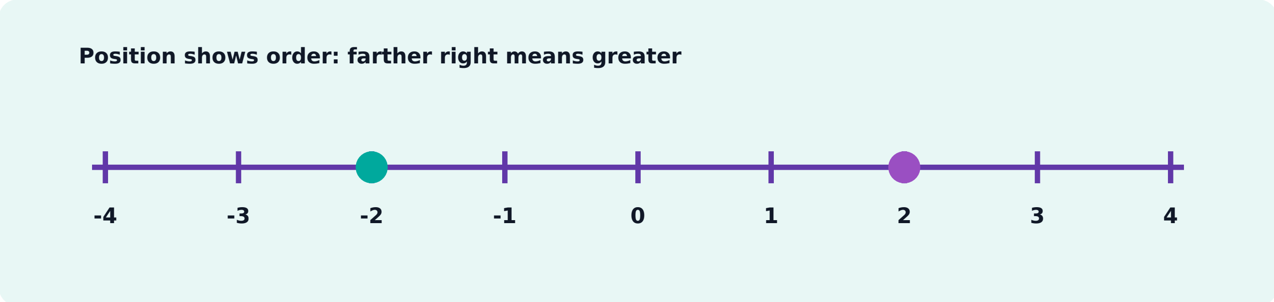
Pearson Edexcel content references N1, N2. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Higher-tier ordering may mix negative numbers, fractions, decimals, percentages, roots and standard form. A comparison is valid only after values are expressed in compatible forms or bounded accurately. Directed arithmetic follows the number line: subtraction adds the opposite, while multiplication and division use sign parity.

KEY VOCABULARY

real number • integer • rational • irrational • inequality • magnitude • reciprocal • directed number



Why the method works

- For negative numbers, greater magnitude means a smaller value.
- A square root can be bounded between consecutive square numbers.
- Cross-multiplication compares positive fractions without decimal approximation.
- An even number of negative factors gives a positive product; an odd number gives a negative product.

CHECK BEFORE MOVING ON

Answer mentally: 1) Insert < or >: $-\sqrt{5}$ ___ -2.3. 2) Order $0.31, 31.2\%, 5/16$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 01 • N1-N2 • METHODS

N1, N2

Ordering real numbers and directed calculation — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Order $-\sqrt{10}$, -3.15, $-22/7$ and -3.1.

1. $\sqrt{10} \approx 3.162$, so $-\sqrt{10} \approx -3.162$.
2. $-22/7 \approx -3.143$.
3. Order from most negative upward.

ANSWER: $-\sqrt{10}$, -3.15, $-22/7$, -3.1

WORKED EXAMPLE 2

Evaluate $-4-3[2-5(-2)]$.

1. Inside: $5(-2)=-10$, so $2-(-10)=12$.
2. Then $-4-36$.

ANSWER: -40

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Evaluate -3^2+5. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 01 • N1-N2 • APPLICATION

N1, N2

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Finance, temperature and displacement models combine signed values. A positive final change can arise from subtracting a negative quantity.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain why $-\sqrt{20}<-4$. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 01 • N1-N2 • PRACTICE

N1, N2

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Insert < or >: $-\sqrt{5}$ ___ -2.3.**
2. **Order 0.31,31.2%,5/16.**
3. **Evaluate -3^2+5.**
4. **Evaluate $(-3)^2+5$.**
5. **Find change from −18 to 7.**
6. **Compare 17/23 and 19/26 exactly.**
7. **Evaluate $-2(3-5)^3$.**
8. **Explain why $-\sqrt{20}<-4$.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 02 • N2-N3

N2, N3

Operation structure, reciprocals and exact arithmetic

Read a complex expression as a hierarchy rather than a calculator string.

SPECIFICATION FOCUS

Pearson Edexcel content references N2, N3. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Brackets, indices, division, multiplication, addition and subtraction define the structure of an expression. Division by a non-zero number is multiplication by its reciprocal. Complex fraction bars act as brackets around complete numerators and denominators. Equivalent rearrangements can expose cancellation before calculation.

KEY VOCABULARY

operation • reciprocal • complex fraction • inverse • BIDMAS • cancellation • exact

Brackets → **Indices** → **÷ and ×** → **+ and −**

Division/multiplication share a level; addition/subtraction share a level. Work left to right.

Why the method works

- Multiplication and division share priority and proceed left to right.
- A fraction bar groups its complete numerator and denominator.
- Dividing by a fraction multiplies by its reciprocal.
- Cancellation is valid between factors, not between terms joined by addition.

CHECK BEFORE MOVING ON

Answer mentally: 1) Evaluate $5-2^3\times3$. 2) Evaluate $(5-2)^3\times3$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 02 • N2-N3 • METHODS

N2, N3

Operation structure, reciprocals and exact arithmetic — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Evaluate $[3-2(5-8)]^2 \div 6$.

1. $5-8=-3$; $3-2(-3)=9$.
2. $9^2 \div 6=81/6$.

ANSWER: 27/2

WORKED EXAMPLE 2

Simplify $(18\times35)/(21\times15)$ without large products.

1. Cancel $18/15=6/5$ and $35/21=5/3$.
2. Product$=(6/5)(5/3)=2$.

ANSWER: 2

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Find reciprocal of $-7/9$. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 02 • N2-N3 • APPLICATION

N2, N3

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Efficient exact calculation reduces calculator dependence and makes later algebraic simplification easier to audit.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain why cancellation across 3+6 is invalid. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 02 • N2-N3 • PRACTICE

N2, N3

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Evaluate $5-2^3\times3$.**

2. **Evaluate $(5-2)^3\times3$.**

3. **Find reciprocal of $-7/9$.**

4. **Calculate $3/5\div9/10$.**

5. **Simplify $(24\times35)/(28\times45)$.**

6. **Evaluate $2-[3-4(1-5)]$.**

7. **Write $1/(2/3+1/6)$.**

8. **Explain why cancellation across $3+6$ is invalid.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

Prime structure, HCF, LCM and divisibility proof

Use unique prime factorisation to solve grouping and synchronisation problems.

SPECIFICATION FOCUS

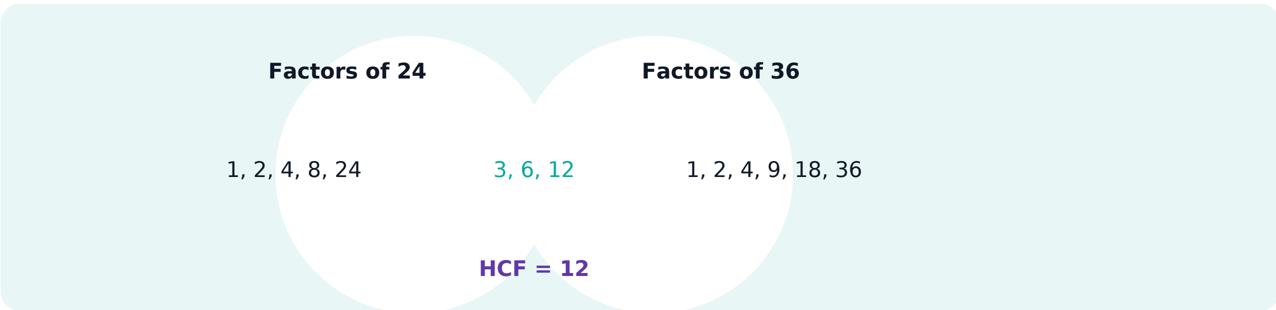
Pearson Edexcel content references N4. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Every integer greater than 1 has a unique prime factorisation apart from factor order. HCF uses common primes with minimum powers; LCM uses every required prime with maximum powers. Prime structure also supports square/cube tests and proofs about divisibility.

KEY VOCABULARY

prime • composite • prime factorisation • HCF • LCM • coprime • divisibility



Why the method works

- Prime factorisation is unique, so exponent comparison is definitive.
- A perfect square has even exponents in its prime factorisation.
- A perfect cube has exponents divisible by three.
- For positive integers a and b, $\text{HCF}(a,b)\times\text{LCM}(a,b)=ab$.

CHECK BEFORE MOVING ON

Answer mentally: 1) Write 756 in prime factors. 2) HCF of 180 and 252. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 03 • N4 • METHODS

N4

Prime structure, HCF, LCM and divisibility proof — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Given $A=2^4\times3^2\times5$ and $B=2^2\times3\times7$, find HCF and LCM.

1. HCF uses $2^2\times3=12$.
2. LCM uses $2^4\times3^2\times5\times7$.

ANSWER: HCF 12; LCM 5040

WORKED EXAMPLE 2

Find the smallest integer multiplying 540 to make a square.

1. $540=2^2\times3^3\times5$.
2. Make exponents even by multiplying 3×5.

ANSWER: 15

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

LCM of 72 and 90. First predict the form or approximate size of the answer; then show a complete method.

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Cryptography, scheduling and gear systems rely on divisibility and repeating cycles. Prime factors reveal structure hidden by decimal calculation.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain square exponent test. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 03 • N4 • PRACTICE

N4

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Write 756 in prime factors.**
2. **HCF of 180 and 252.**
3. **LCM of 72 and 90.**
4. **Smallest multiplier making 360 a square.**
5. **Smallest multiplier making 108 a cube.**
6. **If HCF=6,LCM=420,a=60,find b.**
7. **Are 35 and 64 coprime?**
8. **Explain square exponent test.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 04 • N5

N5

Systematic listing and the product rule for counting

Prove completeness without writing every outcome when stages multiply.

SPECIFICATION FOCUS

Pearson Edexcel content references N5. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

A systematic list changes one feature at a time and prevents repetition. The product rule states that if one stage has m choices and each leads to n choices at the next stage, there are mn combined choices. Restrictions alter the available choices and must be applied at the correct stage.

KEY VOCABULARY

systematic list • product rule • stage • restriction • repetition • outcome

7	11	15	19	...

+4 each time -> nth term 4n + 3

Why the method works

- Independent choice counts multiply across successive stages.
- Without repetition, later choice counts decrease.
- A restriction on the final digit is handled before counting earlier positions when convenient.
- Listing remains useful for verifying a product-rule model in small cases.

CHECK BEFORE MOVING ON

Answer mentally: 1) 3 shirts,4 trousers,2 coats: outfits. 2) Five-letter codes A–Z with repetition. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

Systematic listing and the product rule for counting — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

How many 4-digit codes use digits 0–9 if repetition is allowed?

1. Each of four positions has 10 choices.
2. 10^4.

ANSWER: 10,000

WORKED EXAMPLE 2

How many 3-digit even numbers use 1,2,3,4,5 without repetition?

1. Final digit has 2 choices:2 or4.
2. Hundreds then has 4 choices; tens 3.
3. $2\times4\times3$.

ANSWER: 24

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Choose captain then deputy from 12. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 04 • N5 • APPLICATION

N5

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Passwords, menu choices and experimental designs use the product rule. Security estimates must account for forbidden repetition and fixed formats.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain why 3-digit numbers cannot start zero. Write one sentence explaining why your calculation or conclusion is valid.

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **3 shirts,4 trousers,2 coats: outfits.**
2. **Five-letter codes A–Z with repetition.**
3. **Choose captain then deputy from 12.**
4. **3-digit codes from 0–9 without repetition.**
5. **3-digit numbers from 0–9 without repetition.**
6. **Two dice and coin: outcomes.**
7. **Codes AB? with final digit 0–9.**
8. **Explain why 3-digit numbers cannot start zero.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 05 • N6-N7

N6, N7

Integer indices, roots and estimating powers

Extend repeated multiplication to zero and negative indices and bound unfamiliar roots.

SPECIFICATION FOCUS

Pearson Edexcel content references N6, N7. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Index laws count repeated factors and extend consistently to zero and negative integers. For non-zero a, $a^0=1$ and $a^{-n}=1/a^n$. Roots reverse powers. When a root is not exact, neighbouring perfect powers bound it; interpolation or calculator evaluation may refine the estimate.

KEY VOCABULARY

base • index • zero index • negative index • reciprocal • root • bound

$$3^4 = 3 \times 3 \times 3 \times 3 = 81$$

base = repeated factor   index = number of factors

Why the method works

- $a^m a^n=a^{m+n}$ and $a^m/a^n=a^{m-n}$ for non-zero a.
- $(a^m)^n=a^{mn}$.
- $a^{-n}=1/a^n$.
- If $5^3<140<6^3$, then $5<\sqrt[3]{140}<6$.

CHECK BEFORE MOVING ON

Answer mentally: 1) Evaluate 2^{-4}. 2) Simplify $x^7 \div x^{-2}$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 05 • N6-N7 • METHODS

N6, N7

Integer indices, roots and estimating powers — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Simplify $3^{-2}\times3^{5}\div3$.

1. Combine indices: $-2+5-1=2$.

ANSWER: 9

WORKED EXAMPLE 2

Estimate $\sqrt{70}$ to one decimal place.

1. $8^2=64$ and $9^2=81$.
2. Calculator/refinement gives 8.366...

ANSWER: 8.4

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Simplify $(a^{-3})^4$. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 05 • N6-N7 • APPLICATION

N6, N7

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Scientific scales and algorithmic complexity use powers far beyond direct repeated multiplication. Bounds provide a reasonableness check on calculator output.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain $a^0=1$ using division. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 05 • N6-N7 • PRACTICE

N6, N7

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Evaluate 2^{-4}.**

2. **Simplify $x^7 \div x^{-2}$.**

3. **Simplify $(a^{-3})^4$.**

4. **Find $\sqrt[3]{2744}$.**

5. **Bound $\sqrt{130}$ between integers.**

6. **Estimate 2.7^4 to 2 s.f.**

7. **Solve $5^x = 125$.**

8. **Explain $a^0 = 1$ using division.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 06 • N7

N7

Fractional indices and inverse powers

Interpret the denominator as a root and the numerator as a power.

SPECIFICATION FOCUS

Pearson Edexcel content references N7. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

A fractional index combines powers and roots: $a^{1/n}$ is the principal nth root of a, and $a^{m/n}=(\sqrt[n]{a})^m$. Negative fractional indices add a reciprocal. Equivalent forms allow the root or the power to be evaluated first; choose the order that keeps numbers simple.

KEY VOCABULARY

fractional index • nth root • principal root • reciprocal • rational exponent

$$3^4 = 3 \times 3 \times 3 \times 3 = 81$$

base = repeated factor   index = number of factors

Why the method works

- $a^{1/n}=\sqrt[n]{a}$ for appropriate real a.
- $a^{m/n}=(\sqrt[n]{a})^m=a^m$ then nth root where defined.
- $a^{-m/n}=1/a^{m/n}$.
- An even root of a negative real number is not real.

CHECK BEFORE MOVING ON

Answer mentally: 1) Evaluate $25^{1/2}$. 2) Evaluate $27^{2/3}$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

Fractional indices and inverse powers — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Evaluate $64^{2/3}$.

1. Cube root 64=4.
2. Square:4^2.

ANSWER: 16

WORKED EXAMPLE 2

Evaluate $81^{-3/4}$.

1. Fourth root 81=3; cube=27.
2. Negative index gives reciprocal.

ANSWER: 1/27

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Evaluate $16^{3/4}$. First predict the form or approximate size of the answer; then show a complete method.

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Scaling laws often use fractional exponents, such as recovering a length scale from an area or volume scale.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain two orders for $a^{4/3}$. Write one sentence explaining why your calculation or conclusion is valid.

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Evaluate $25^{1/2}$.**
2. **Evaluate $27^{2/3}$.**
3. **Evaluate $16^{3/4}$.**
4. **Evaluate $32^{-2/5}$.**
5. **Write cube root x as a power.**
6. **Write $1/\sqrt{a}$ as a power.**
7. **Solve $x^3=125$ using index notation.**
8. **Explain two orders for $a^{4/3}$.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

Surds and exact radical arithmetic

Simplify roots by extracting square factors and keep irrational values exact.

SPECIFICATION FOCUS

Pearson Edexcel content references N8. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

A surd is an irrational root left in exact form. To simplify $\sqrt{n}$, factor n into a perfect square and another factor. Like surds combine through their numerical coefficients. Products use $\sqrt{a}\sqrt{b}=\sqrt{(ab)}$ for non-negative a and b. Addition does not combine unlike radicands.

KEY VOCABULARY

surd • irrational • radicand • square factor • like surds • exact

$$3^4 = 3 \times 3 \times 3 \times 3 = 81$$

base = repeated factor   index = number of factors

Why the method works

- $\sqrt{(k^2m)}=k\sqrt{m}$ for positive k.
- $p\sqrt{a}+q\sqrt{a}=(p+q)\sqrt{a}$.
- $\sqrt{a}\sqrt{b}=\sqrt{(ab)}$ for non-negative a,b.
- $(a+b\sqrt{c})(a-b\sqrt{c})=a^2-b^2c$.

CHECK BEFORE MOVING ON

Answer mentally: 1) Simplify $\sqrt{72}$. 2) Simplify $\sqrt{147}$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

Surds and exact radical arithmetic — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Simplify $\sqrt{180}$.

1. $180=36\times5$.
2. $\sqrt{180}=6\sqrt{5}$.

ANSWER: $6\sqrt{5}$

WORKED EXAMPLE 2

Simplify $3\sqrt{8}+2\sqrt{18}-\sqrt{50}$.

1. $\sqrt{8}=2\sqrt{2}$, $\sqrt{18}=3\sqrt{2}$, $\sqrt{50}=5\sqrt{2}$.
2. $6\sqrt{2}+6\sqrt{2}-5\sqrt{2}$.

ANSWER: $7\sqrt{2}$

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Simplify $5\sqrt{12}-\sqrt{27}$. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 07 • N8 • APPLICATION

N8

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Exact diagonal lengths and trigonometric results often contain surds. Preserving them avoids approximation drift.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain why $\sqrt{2}+\sqrt{3}\neq\sqrt{5}$. Write one sentence explaining why your calculation or conclusion is valid.

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Simplify $\sqrt{72}$.**

2. **Simplify $\sqrt{147}$.**

3. **Simplify $5\sqrt{12}-\sqrt{27}$.**

4. **Calculate $\sqrt{6}\times\sqrt{24}$.**

5. **Expand $(3+\sqrt{5})(2-\sqrt{5})$.**

6. **Simplify $\sqrt{48}/\sqrt{3}$.**

7. **Is $\sqrt{49}$ a surd?**

8. **Explain why $\sqrt{2}+\sqrt{3}\neq\sqrt{5}$.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 08 • N8

N8

Rationalising denominators and conjugates

Remove surds from denominators while preserving exact value.

SPECIFICATION FOCUS

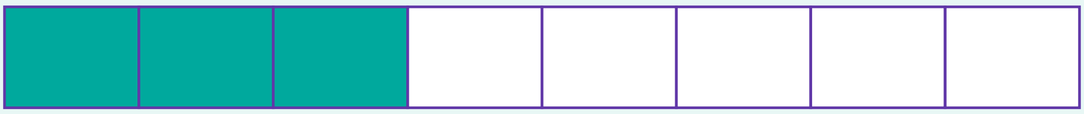
Pearson Edexcel content references N8. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Rationalising rewrites an equivalent fraction with a rational denominator. For a single surd denominator, multiply numerator and denominator by that surd. For a binomial $a+\sqrt{b}$, multiply by its conjugate $a-\sqrt{b}$ so the denominator becomes a difference of squares.

KEY VOCABULARY

rationalise • denominator • conjugate • equivalent fraction • difference of squares



3 shaded equal parts out of 8 = 3/8

Why the method works

- Multiplying top and bottom by the same non-zero expression preserves value.
- $\sqrt{a}\times\sqrt{a}=a$ for $a\geq 0$.
- Conjugates eliminate the middle surd terms.
- The final expression should be simplified fully.

CHECK BEFORE MOVING ON

Answer mentally: 1) Rationalise $7/\sqrt{2}$. 2) Rationalise $3/\sqrt{12}$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

Rationalising denominators and conjugates — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Rationalise $5/\sqrt{3}$.

1. Multiply by $\sqrt{3}/\sqrt{3}$.

ANSWER: $5\sqrt{3}/3$

WORKED EXAMPLE 2

Rationalise $4/(3+\sqrt{5})$.

1. Multiply by $(3-\sqrt{5})/(3-\sqrt{5})$.
2. Denominator$=9-5=4$; cancel 4.

ANSWER: $3-\sqrt{5}$

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Rationalise $1/(2+\sqrt{3})$. First predict the form or approximate size of the answer; then show a complete method.

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Exact algebraic and geometric answers are easier to compare when denominators are rational and expressions are simplified consistently.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain why conjugates work. Write one sentence explaining why your calculation or conclusion is valid.

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Rationalise $7/\sqrt{2}$.**
2. **Rationalise $3/\sqrt{12}$.**
3. **Rationalise $1/(2+\sqrt{3})$.**
4. **Rationalise $5/(\sqrt{7}-2)$.**
5. **Simplify $6/(3\sqrt{2})$.**
6. **Find conjugate of $4-\sqrt{11}$.**
7. **Expand $(5+\sqrt{2})(5-\sqrt{2})$.**
8. **Explain why conjugates work.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 09 • N2, N8, N10-N12

N2, N8, N10, N11, N12

Fraction structure, operators and exact proportional reasoning

Manipulate complex fractions and interpret a fraction as both number and operator.

SPECIFICATION FOCUS

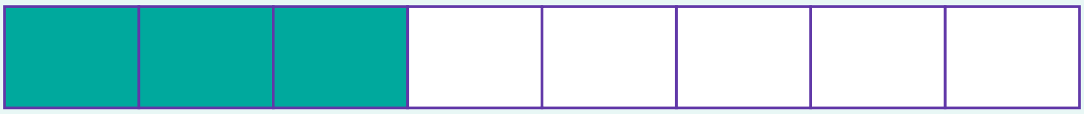
Pearson Edexcel content references N2, N8, N10, N11, N12. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Fractions encode division, ratio and an operator. Higher problems often nest fractions or combine algebraic-looking numerical structure. Exact addition needs a common denominator; multiplication permits factor cancellation; division uses reciprocals. Terminating decimals correspond to fractions whose simplified denominators contain only factors 2 and 5.

KEY VOCABULARY

proper • improper • mixed number • operator • complex fraction • terminating decimal



3 shaded equal parts out of 8 = 3/8

Why the method works

- A common denominator creates equal-sized parts for addition.
- Cancellation occurs between factors in multiplication.
- A simplified denominator with primes other than 2 or 5 produces a recurring decimal.
- A fraction greater than one is a valid multiplier and proportion.

CHECK BEFORE MOVING ON

Answer mentally: 1) Calculate $5/6-7/15$. 2) Calculate $9/14\div3/7$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 09 • N2, N8, N10-N12 • METHODS

N2, N8, N10, N11, N12

Fraction structure, operators and exact proportional reasoning — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Evaluate (3/4−2/5)/(7/10).

1. Top=15/20−8/20=7/20.
2. Divide by 7/10: (7/20)(10/7).

ANSWER: 1/2

WORKED EXAMPLE 2

Determine whether 21/360 terminates.

1. Simplify to 7/120.
2. $120=2^3\times3\times5$ contains factor 3.

ANSWER: Recurring

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Evaluate (1/2+1/3)/(5/6). First predict the form or approximate size of the answer; then show a complete method.

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Chemical concentrations and scale relationships require exact fraction operations before measurements are rounded.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain denominator prime-factor test. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 09 • N2, N8, N10-N12 • PRACTICE

N2, N8, N10, N11, N12

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Calculate $5/6-7/15$.**
2. **Calculate $9/14\div3/7$.**
3. **Evaluate $(1/2+1/3)/(5/6)$.**
4. **Is 13/40 terminating?**
5. **Is 7/45 terminating?**
6. **Find 7/8 of 2/3.**
7. **Write 2.375 as a fraction.**
8. **Explain denominator prime-factor test.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 10 • N10

N10

Recurring decimals as exact fractions

Use algebraic shifting to remove the repeating tail exactly.

SPECIFICATION FOCUS

Pearson Edexcel content references N10. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

A recurring decimal is rational because its repeating block can be eliminated by multiplying by an appropriate power of ten and subtracting. One recurring digit uses $10x-x$; a block of k digits uses $10^k x-x$. A non-recurring prefix may require an additional shift or careful subtraction.

KEY VOCABULARY

recurring decimal • recurring block • rational • algebraic shift • exact fraction

100s	10s	1s	.	tenths	hundredths	thousandths
4	0	7	.	3	0	5

Why the method works

- Multiplying by 10^k aligns identical recurring tails.
- Subtracting cancels the infinite repeated part.
- The resulting linear equation gives an exact fraction.
- Substitution or division checks the recurring pattern.

CHECK BEFORE MOVING ON

Answer mentally: 1) Convert 0.333… . 2) Convert 0.4545… . 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

Recurring decimals as exact fractions — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Convert 0.272727... to a fraction.

1. Let $x=0.272727...$.
2. $100x=27.272727...$.
3. $99x=27$.

ANSWER: 3/11

WORKED EXAMPLE 2

Convert 0.1666... to a fraction.

1. Let $x=0.1666...$.
2. $10x=1.666...$, $100x=16.666...$.
3. $90x=15$.

ANSWER: 1/6

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Convert 0.125125... . First predict the form or approximate size of the answer; then show a complete method.

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Repeating digital measurements and rational models can be stored exactly as fractions rather than truncated decimals.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain why every recurring decimal is rational. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 10 • N10 • PRACTICE

N10

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Convert 0.333… .**
2. **Convert 0.4545… .**
3. **Convert 0.125125… .**
4. **Convert 0.2777… .**
5. **Convert 1.363636… .**
6. **Show 0.999…=1.**
7. **Which multiplier for block 407?**
8. **Explain why every recurring decimal is rational.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

Standard form across multiple operations

Separate significant-number arithmetic from powers of ten and normalise once.

SPECIFICATION FOCUS

Pearson Edexcel content references N9. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Standard form writes $A\times10^n$ with $1\le|A|<10$. Multiplication adds indices, division subtracts them, and addition or subtraction first requires a common power of ten. A result is normalised by shifting the coefficient and compensating in the index.

KEY VOCABULARY

standard form • coefficient • exponent • order of magnitude • normalise

$$4.7 \times 10^5 = 470{,}000$$

positive power → move decimal point right

1 ≤ first number < 10

Why the method works

- Multiplication: multiply coefficients and add exponents.
- Division: divide coefficients and subtract exponents.
- Addition/subtraction requires matching powers of ten.
- Moving the decimal left raises the exponent; moving it right lowers the exponent.

CHECK BEFORE MOVING ON

Answer mentally: 1) $(3\times10^5)(8\times10^{-2})$. 2) $(9\times10^7)/(3\times10^{-5})$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

Standard form across multiple operations — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Calculate $(6\times10^{7})(3.5\times10^{-4})$.

1. Coefficients$=21$; exponent$=3$.
2. $21\times10^{3}=2.1\times10^{4}$.

ANSWER: 2.1×10^{4}

WORKED EXAMPLE 2

Calculate $4.2\times10^{6}-7.5\times10^{5}$.

1. Rewrite $7.5\times10^{5}=0.75\times10^{6}$.
2. Difference$=3.45\times10^{6}$.

ANSWER: 3.45×10^{6}

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

$2.4\times10^{6}+7\times10^{5}$. First predict the form or approximate size of the answer; then show a complete method.

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Astronomy and microscopic science compare orders of magnitude. Standard form exposes scale while preserving significant digits.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain common exponent for addition. Write one sentence explaining why your calculation or conclusion is valid.

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **$(3\times10^{5})(8\times10^{-2})$.**
2. **$(9\times10^{7})/(3\times10^{-5})$.**
3. **$2.4\times10^{6}+7\times10^{5}$.**
4. **$5\times10^{-3}-8\times10^{-4}$.**
5. **Normalise 34×10^{9}.**
6. **Order $7\times10^{-5},9\times10^{-6},2\times10^{-4}$.**
7. **How many times larger 6×10^{8} than 2×10^{5}?**
8. **Explain common exponent for addition.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 12 • N12, R9, R16

N12; linked R9, R16

Percentage operators, reverse percentages and repeated change

Model every change with a multiplier and distinguish original from current value.

SPECIFICATION FOCUS

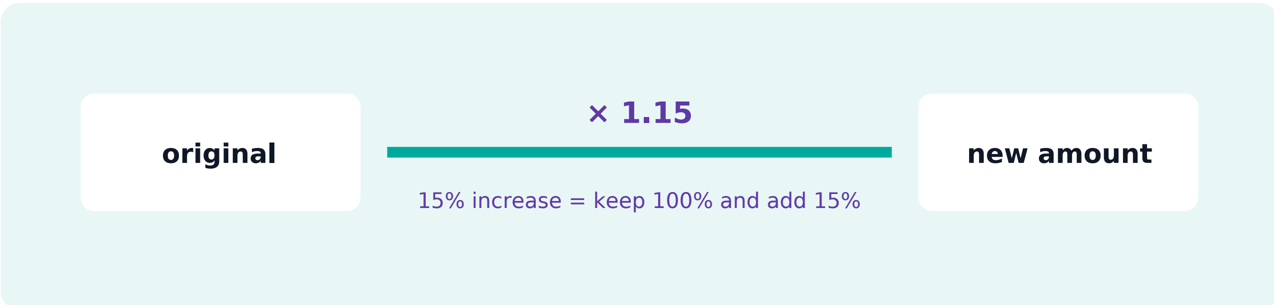
Pearson Edexcel content references N12; linked R9, R16. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

A percentage is an operator. Increase by p% uses $1+p/100$; decrease uses $1-p/100$. Repeated change multiplies successive factors because each percentage acts on a new current value. Reverse percentages divide by the multiplier. Compound growth follows $\text{original}\times\text{multiplier}^n$.

KEY VOCABULARY

multiplier • reverse percentage • compound growth • decay • original value • repeated change



Why the method works

- Successive percentage changes compose by multiplying, not adding.
- Reverse percentage divides by the complete multiplier.
- Equal percentage rise and fall do not cancel.
- Compound change uses a changing base; simple change uses the original base.

CHECK BEFORE MOVING ON

Answer mentally: 1) Increase 640 by 17%. 2) Decrease 920 by 14%. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 12 • N12, R9, R16 • METHODS

N12; linked R9, R16

Percentage operators, reverse percentages and repeated change — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

A value rises 18% then falls 12%. Find overall percentage change.

1. Combined multiplier$=1.18\times0.88=1.0384$.
2. Final is 103.84% of original.

ANSWER: 3.84% increase

WORKED EXAMPLE 2

After 15% depreciation, a car is worth £13,600. Find previous value.

1. $0.85\times\text{original}=13{,}600$.
2. Divide by 0.85.

ANSWER: £16,000

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Reverse 25% increase gives 875. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 12 • N12, R9, R16 • APPLICATION

N12; linked R9, R16

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Inflation, investment and depreciation require explicit multiplier models and careful interpretation of the base amount.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain why $+10\%, -10\%$ gives -1%. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 12 • N12, R9, R16 • PRACTICE

N12; linked R9, R16

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Increase 640 by 17%.**
2. **Decrease 920 by 14%.**
3. **Reverse 25% increase gives 875.**
4. **Reverse 20% decrease gives 560.**
5. **£2000 grows 4% for 3 years.**
6. **12% rise then 12% fall: multiplier.**
7. **Find annual multiplier for 7% decay.**
8. **Explain why +10%,−10% gives −1%.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 13 • N13

N13

Unit systems and compound-measure conversion

Track numerator and denominator conversions separately.

SPECIFICATION FOCUS

Pearson Edexcel content references N13. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Higher unit conversion may involve area, volume and compound rates. A linear conversion factor is squared for area and cubed for volume. For a compound unit, convert the numerator and denominator independently; for example km/h to m/s multiplies by 1000 and divides by 3600. Dimensional checking exposes many incorrect formulas.

KEY VOCABULARY

dimension • compound unit • conversion factor • density • pressure • rate

Understand | **Choose** | **Calculate** | **Check** | **Interpret**

A reliable solution is a chain of decisions, not only a calculator display.

Why the method works

- Length factor k gives area factor k^2 and volume factor k^3.
- A unit written “per” is a quotient.
- Converting the denominator reverses its effect on the numerical rate.
- Dimensional consistency is a necessary check on a formula.

CHECK BEFORE MOVING ON

Answer mentally: 1) Convert 108 km/h to m/s. 2) Convert 12 m/s to km/h. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

Unit systems and compound-measure conversion — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Convert 54 km/h to m/s.

1. $54 \times 1000/3600$.

ANSWER: 15 m/s

WORKED EXAMPLE 2

Convert 2.7 g/cm³ to kg/m³.

1. 1 g=0.001 kg; 1 $\text{cm}^3=10^{-6}\ \text{m}^3$.
2. $2.7 \times 0.001/10^{-6}$.

ANSWER: 2700 kg/m³

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Convert 3.5 m^2 to cm^2. First predict the form or approximate size of the answer; then show a complete method.

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Engineering specifications use compound units; an unnoticed square or cube conversion can create errors by factors of thousands.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain denominator conversion direction. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 13 • N13 • PRACTICE

N13

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Convert 108 km/h to m/s.**

2. **Convert 12 m/s to km/h.**

3. **Convert 3.5 m^2 to cm^2.**

4. **Convert 0.04 m^3 to cm^3.**

5. **Convert 1.2 g/cm^3 to kg/m^3.**

6. **£4.80 per 600 g: £/kg.**

7. **Pressure 2400 N over 0.8 m^2.**

8. **Explain denominator conversion direction.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 14 • N14-N15

N14, N15

Estimation, significant figures and numerical error

Predict scale before calculating and preserve only justified precision.

SPECIFICATION FOCUS

Pearson Edexcel content references N14, N15. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Estimation replaces values with convenient nearby numbers to predict order of magnitude. Significant figures begin at the first non-zero digit, while decimal places count positions after the decimal point. Rounding introduces error, so intermediate values should usually remain unrounded. A final answer should reflect measurement precision and context.

KEY VOCABULARY

estimate • approximation • significant figure • decimal place • absolute error • relative error

3.472 lies above 3.45, so it rounds to 3.5 to 1 decimal place

Why the method works

- Estimation is a check, not a substitute for an exact requested calculation.
- Leading zeros do not count as significant figures.
- Premature rounding can accumulate through multi-step work.
- Relative error compares absolute error with the true or accepted magnitude.

CHECK BEFORE MOVING ON

Answer mentally: 1) Round 0.006784 to 3 s.f. 2) Round 48,951 to 2 s.f. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 14 • N14-N15 • METHODS

N14, N15

Estimation, significant figures and numerical error — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

Estimate $(398\times0.049)/(2.03^2)$.

1. Use $400\times0.05/2^2=20/4$.

ANSWER: 5

WORKED EXAMPLE 2

A value 8.47 is approximated as 8.5. Find absolute error.

1. $|8.5-8.47|$.

ANSWER: 0.03

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Estimate $19.7^2/0.098$. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 14 • N14-N15 • APPLICATION

N14, N15

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Scientific reporting matches precision to evidence. Extra calculator digits do not create extra measurement accuracy.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain order-of-magnitude check. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 14 • N14-N15 • PRACTICE

N14, N15

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Round 0.006784 to 3 s.f.**
2. **Round 48,951 to 2 s.f.**
3. **Estimate $19.7^2/0.098$.**
4. **Accepted 50,estimate 49.2: absolute error.**
5. **Same: percentage error.**
6. **Why retain guard digits?**
7. **State 3.40 significant figures.**
8. **Explain order-of-magnitude check.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 15 • N15-N16

N15, N16

Bounds and limits of accuracy in multi-step calculations

Choose the combination of endpoints that truly maximises or minimises the expression.

SPECIFICATION FOCUS

Pearson Edexcel content references N15, N16. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

A rounded value represents a half-open interval. Bounds propagate through calculations. For positive quantities, products and quotients use endpoint combinations: maximum a/b uses upper a and lower b; minimum uses lower a and upper b. Addition and subtraction require analysing how each variable affects the expression. Rounded counts may instead be exact integers, so context matters.

KEY VOCABULARY

error interval • lower bound • upper bound • maximum • minimum • tolerance • limit

Why the method works

- Nearest unit u gives half-width u/2.
- For positive a,b, upper(a/b)=aU/bL and lower(a/b)=aL/bU.
- For a−b, maximum uses aU−bL and minimum aL−bU.
- Final bounds should not be rounded inward.

CHECK BEFORE MOVING ON

Answer mentally: 1) 24 nearest integer: interval. 2) 3.60 nearest 0.01: interval. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 15 • N15-N16 • METHODS

N15, N16

Bounds and limits of accuracy in multi-step calculations — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

L=8.4 cm nearest 0.1 and T=3.2 s nearest 0.1. Find upper bound L/T.

1. $L<8.45$ and $T\geq 3.15$.
2. Upper bound $=8.45/3.15$.

ANSWER: 2.6825... cm/s

WORKED EXAMPLE 2

Rectangle 12.0 by 7.0 cm, each nearest 0.1. Find lower-bound area.

1. Lower lengths 11.95 and 6.95.
2. Multiply.

ANSWER: 83.0525 cm^2

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

$a=10,b=4$ nearest integers: upper a/b. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 15 • N15-N16 • APPLICATION

N15, N16

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Manufacturing and dosage calculations use worst-case bounds to guarantee clearance, capacity or safety.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

Explain why quotient uses opposite endpoints. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 15 • N15-N16 • PRACTICE

N15, N16

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **24 nearest integer: interval.**
2. **3.60 nearest 0.01: interval.**
3. **a=10,b=4 nearest integers: upper a/b.**
4. **Same: lower a/b.**
5. **x=7,y=2 nearest integers: upper x−y.**
6. **Rectangle 5.2×3.8 nearest0.1: upper area.**
7. **Mass 2.4 kg nearest0.1,volume0.8 L nearest0.1: lower density.**
8. **Explain why quotient uses opposite endpoints.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

CHAPTER 16 • N1-N16

N1-N16 synthesis

Higher Number modelling, proof and multi-stage reasoning

Connect exact structure, approximation and contextual constraints in one solution.

SPECIFICATION FOCUS

Pearson Edexcel content references N1-N16 synthesis. This lesson develops representation, accurate calculation and interpretation within Higher Tier problem solving.

Understand the idea

Higher Number problems rarely announce a single technique. A complete solution may combine prime structure, surds, standard form, percentages, units and bounds. The reasoning should distinguish exact identities from estimates, preserve accuracy across stages and evaluate whether assumptions or integer constraints affect the conclusion.

KEY VOCABULARY

model • proof • counterexample • constraint • exact • estimate • bound • interpretation

Understand | Choose | Calculate | Check | Interpret

A reliable solution is a chain of decisions, not only a calculator display.

Why the method works

- A chain of reasoning is only as reliable as its least justified step.
- Exact forms should be preserved until approximation is required.
- Integer and physical constraints can reject mathematically valid numerical results.
- Alternative methods and inverse checks strengthen verification.

CHECK BEFORE MOVING ON

Answer mentally: 1) Simplify $\sqrt{75}+\sqrt{12}$. 2) Rationalise $6/\sqrt{3}$. 3) State one definition or rule from this page in your own words.

EXPLAIN IT

Complete this sentence: “The method works because …” Use the key vocabulary above and refer to the representation in the diagram.

CHAPTER 16 • N1-N16 • METHODS

N1-N16 synthesis

Higher Number modelling, proof and multi-stage reasoning — method and examples

Follow the reasoning; do not copy steps mechanically.

Reliable method

- Identify the mathematical structure before calculating.
- Choose an exact, algebraic or numerical representation.
- Carry out each transformation with a stated reason.
- Check restrictions, magnitude, accuracy and units.

WORKED EXAMPLE 1

A square has exact area 180 cm². Find exact perimeter and decimal to 3 s.f.

1. Side $=\sqrt{180}=6\sqrt{5}$.
2. Perimeter $=24\sqrt{5}\approx 53.6656$.

ANSWER: $24\sqrt{5}$ cm; 53.7 cm

WORKED EXAMPLE 2

A population 2.4×10^6 grows 3.2% annually for 5 years. Estimate final population.

1. Model $=2.4\times10^6\times1.032^5$.
2. Evaluate then round to a sensible whole number.

ANSWER: about 2.81×10^6

SELF-CHECK QUESTION

Which step carries the mathematical reason, and which step carries only arithmetic? Being able to distinguish them makes it easier to repair errors.

GUIDED TRY

Convert 0.1818... to fraction. First predict the form or approximate size of the answer; then show a complete method.

CHAPTER 16 • N1-N16 • APPLICATION

N1-N16 synthesis

Apply and reason

Connect the method to a context and communicate the conclusion.

Real-world model

CONTEXT

Financial forecasts, engineering tolerances and scientific models require both correct mathematics and explicit assumptions.

Common mistakes and how to repair them

MISTAKE 1

Applying a remembered rule without checking its conditions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 2

Rounding an intermediate value and losing accuracy. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

MISTAKE 3

Giving a result without testing its magnitude or restrictions. Repair: return to the definition, write one complete mathematical line, then check the size or sign of the result.

Exam communication

- Write the operation or equation before the answer.
- Preserve exact values unless the question asks for rounding.
- Attach units and interpret the final value in the context.

REASONING PROMPT

State two checks on a multi-stage model. Write one sentence explaining why your calculation or conclusion is valid.

CHAPTER 16 • N1-N16 • PRACTICE

N1-N16 synthesis

Independent practice

Complete without notes, then use the answer section to diagnose errors.

1. **Simplify $\sqrt{75}+\sqrt{12}$.**
2. **Rationalise $6/\sqrt{3}$.**
3. **Convert 0.1818… to fraction.**
4. **$(4\times10^{5})(7\times10^{-3})$.**
5. **£800 grows 6% for 4 years.**
6. **Smallest n making 90n a square.**
7. **Upper bound 6.2/1.8 both nearest0.1.**
8. **State two checks on a multi-stage model.**

REFLECTION

Circle one: secure / almost / reteach. Write the question number of your most useful error and the rule that repairs it.

PRACTICE ANSWERS

CHAPTER 01

Answers, method guidance and repair notes

Ordering real numbers and directed calculation

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Insert < or >: $-\sqrt{5}$ ___ -2.3. **ANSWER: >**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Order 0.31,31.2%,5/16. **ANSWER: 0.31,31.2%,5/16**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Evaluate -3^2+5. **ANSWER: −4**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Evaluate $(-3)^2+5$. **ANSWER: 14**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Find change from −18 to 7. **ANSWER: 25**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Compare 17/23 and 19/26 exactly. **ANSWER: 17/23>19/26 because 442>437**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Evaluate $-2(3-5)^3$. **ANSWER: 16**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain why $-\sqrt{20}<-4$. **ANSWER: $\sqrt{20}>4$, then negate**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 02

Answers, method guidance and repair notes

Operation structure, reciprocals and exact arithmetic

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Evaluate $5-2^3\times3$. **ANSWER: −19**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Evaluate $(5-2)^3\times3$. **ANSWER: 81**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Find reciprocal of $-7/9$. **ANSWER: $-9/7$**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Calculate $3/5\div9/10$. **ANSWER: $2/3$**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Simplify $(24\times35)/(28\times45)$. **ANSWER: $2/3$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Evaluate $2-[3-4(1-5)]$. **ANSWER: −13**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Write $1/(2/3+1/6)$. **ANSWER: $6/5$**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain why cancellation across 3+6 is invalid. **ANSWER: addition terms are not factors**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 03

Answers, method guidance and repair notes

Prime structure, HCF, LCM and divisibility proof

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Write 756 in prime factors. **ANSWER: $2^2\times3^3\times7$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. HCF of 180 and 252. **ANSWER: 36**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. LCM of 72 and 90. **ANSWER: 360**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Smallest multiplier making 360 a square. **ANSWER: 10**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Smallest multiplier making 108 a cube. **ANSWER: 2**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. If HCF=6,LCM=420,a=60,find b. **ANSWER: 42**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Are 35 and 64 coprime? **ANSWER: yes**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain square exponent test. **ANSWER: all prime factors paired**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 04

Answers, method guidance and repair notes

Systematic listing and the product rule for counting

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. 3 shirts,4 trousers,2 coats: outfits. **ANSWER: 24**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Five-letter codes A–Z with repetition. **ANSWER: 26^5**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Choose captain then deputy from 12. **ANSWER: 132**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. 3-digit codes from 0–9 without repetition. **ANSWER: 720**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. 3-digit numbers from 0–9 without repetition. **ANSWER: 648**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Two dice and coin: outcomes. **ANSWER: 72**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Codes AB? with final digit 0–9. **ANSWER: 10**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain why 3-digit numbers cannot start zero. **ANSWER: leading zero gives 2-digit number**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 05

Answers, method guidance and repair notes

Integer indices, roots and estimating powers

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Evaluate 2^{-4}. **ANSWER: 1/16**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Simplify $x^7 \div x^{-2}$. **ANSWER: x^9**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Simplify $(a^{-3})^4$. **ANSWER: a^{-12}**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Find $\sqrt[3]{2744}$. **ANSWER: 14**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Bound $\sqrt{130}$ between integers. **ANSWER: $11<\sqrt{130}<12$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Estimate 2.7^4 to 2 s.f. **ANSWER: 53**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Solve $5^x=125$. **ANSWER: 3**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain $a^0=1$ using division. **ANSWER: $a^m/a^m=1=a^0$**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 06

Answers, method guidance and repair notes

Fractional indices and inverse powers

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Evaluate $25^{1/2}$. **ANSWER: 5**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Evaluate $27^{2/3}$. **ANSWER: 9**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Evaluate $16^{3/4}$. **ANSWER: 8**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Evaluate $32^{-2/5}$. **ANSWER: 1/4**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Write cube root x as a power. **ANSWER: $x^{1/3}$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Write $1/\sqrt{a}$ as a power. **ANSWER: $a^{-1/2}$**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Solve $x^3=125$ using index notation. **ANSWER: 5**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain two orders for $a^{4/3}$. **ANSWER: cube root then fourth power or power then root**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 07

Answers, method guidance and repair notes

Surds and exact radical arithmetic

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Simplify $\sqrt{72}$. **ANSWER: $6\sqrt{2}$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Simplify $\sqrt{147}$. **ANSWER: $7\sqrt{3}$**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Simplify $5\sqrt{12}-\sqrt{27}$. **ANSWER: $7\sqrt{3}$**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Calculate $\sqrt{6}\times\sqrt{24}$. **ANSWER: 12**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Expand $(3+\sqrt{5})(2-\sqrt{5})$. **ANSWER: $1-\sqrt{5}$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Simplify $\sqrt{48}/\sqrt{3}$. **ANSWER: 4**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Is $\sqrt{49}$ a surd? **ANSWER: no**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain why $\sqrt{2}+\sqrt{3}\neq\sqrt{5}$. **ANSWER: addition rule does not combine radicands**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 08

Answers, method guidance and repair notes

Rationalising denominators and conjugates

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Rationalise $7/\sqrt{2}$. **ANSWER: $7\sqrt{2}/2$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Rationalise $3/\sqrt{12}$. **ANSWER: $\sqrt{3}/2$**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Rationalise $1/(2+\sqrt{3})$. **ANSWER: $2-\sqrt{3}$**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Rationalise $5/(\sqrt{7}-2)$. **ANSWER: $(5\sqrt{7}+10)/3$**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Simplify $6/(3\sqrt{2})$. **ANSWER: $\sqrt{2}$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Find conjugate of $4-\sqrt{11}$. **ANSWER: $4+\sqrt{11}$**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Expand $(5+\sqrt{2})(5-\sqrt{2})$. **ANSWER: 23**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain why conjugates work. **ANSWER: middle terms cancel**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 09

Answers, method guidance and repair notes

Fraction structure, operators and exact proportional reasoning

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Calculate 5/6−7/15. **ANSWER: 11/30**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Calculate 9/14÷3/7. **ANSWER: 3/2**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Evaluate (1/2+1/3)/(5/6). **ANSWER: 1**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Is 13/40 terminating? **ANSWER: yes**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Is 7/45 terminating? **ANSWER: no**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Find 7/8 of 2/3. **ANSWER: 7/12**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Write 2.375 as a fraction. **ANSWER: 19/8**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain denominator prime-factor test. **ANSWER: only 2s and 5s terminate**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 10

Answers, method guidance and repair notes

Recurring decimals as exact fractions

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Convert 0.333… . **ANSWER: 1/3**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Convert 0.4545… . **ANSWER: 5/11**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Convert 0.125125… . **ANSWER: 125/999**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Convert 0.2777… . **ANSWER: 5/18**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Convert 1.363636… . **ANSWER: 15/11**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Show 0.999…=1. **ANSWER: let x=0.999…,9x=9**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Which multiplier for block 407? **ANSWER: 1000**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain why every recurring decimal is rational. **ANSWER: algebra gives ratio of integers**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 11

Answers, method guidance and repair notes

Standard form across multiple operations

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. $(3\times10^{5})(8\times10^{-2})$. **ANSWER: 2.4×10^{4}**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. $(9\times10^{7})/(3\times10^{-5})$. **ANSWER: 3×10^{12}**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. $2.4\times10^{6}+7\times10^{5}$. **ANSWER: 3.1×10^{6}**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. $5\times10^{-3}-8\times10^{-4}$. **ANSWER: 4.2×10^{-3}**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Normalise 34×10^{9}. **ANSWER: 3.4×10^{10}**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Order $7\times10^{-5},9\times10^{-6},2\times10^{-4}$. **ANSWER: $9\times10^{-6},7\times10^{-5},2\times10^{-4}$**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. How many times larger 6×10^{8} than 2×10^{5}? **ANSWER: 3000**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain common exponent for addition. **ANSWER: coefficients represent same units**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 12

Answers, method guidance and repair notes

Percentage operators, reverse percentages and repeated change

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Increase 640 by 17%. **ANSWER: 748.8**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Decrease 920 by 14%. **ANSWER: 791.2**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Reverse 25% increase gives 875. **ANSWER: 700**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Reverse 20% decrease gives 560. **ANSWER: 700**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. £2000 grows 4% for 3 years. **ANSWER: £2249.73**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. 12% rise then 12% fall: multiplier. **ANSWER: 0.9856**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Find annual multiplier for 7% decay. **ANSWER: 0.93**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain why +10%,−10% gives −1%. **ANSWER: $1.1\times0.9=0.99$**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS
CHAPTER 13

Answers, method guidance and repair notes

Unit systems and compound-measure conversion

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Convert 108 km/h to m/s. **ANSWER: 30 m/s**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Convert 12 m/s to km/h. **ANSWER: 43.2 km/h**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Convert 3.5 m^2 to cm^2. **ANSWER: 35,000 cm^2**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Convert 0.04 m^3 to cm^3. **ANSWER: 40,000 cm^3**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Convert 1.2 g/cm^3 to kg/m^3. **ANSWER: 1200 kg/m^3**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. £4.80 per 600 g: £/kg. **ANSWER: £8/kg**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Pressure 2400 N over 0.8 m^2. **ANSWER: 3000 Pa**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain denominator conversion direction. **ANSWER: smaller denominator unit increases count per named unit**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 14

Answers, method guidance and repair notes

Estimation, significant figures and numerical error

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Round 0.006784 to 3 s.f. **ANSWER: 0.00678**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Round 48,951 to 2 s.f. **ANSWER: 49,000**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Estimate $19.7^2/0.098$. **ANSWER: about 4000**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Accepted 50,estimate 49.2: absolute error. **ANSWER: 0.8**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. Same: percentage error. **ANSWER: 1.6%**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Why retain guard digits? **ANSWER: reduce accumulated rounding**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. State 3.40 significant figures. **ANSWER: 3**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain order-of-magnitude check. **ANSWER: detects powers-of-ten mistakes**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 15

Answers, method guidance and repair notes

Bounds and limits of accuracy in multi-step calculations

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. 24 nearest integer: interval. **ANSWER: $23.5 \le x < 24.5$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. 3.60 nearest 0.01: interval. **ANSWER: $3.595 \le x < 3.605$**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. $a=10, b=4$ nearest integers: upper a/b. **ANSWER: $10.5/3.5=3$**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. Same: lower a/b. **ANSWER: $9.5/4.5$**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. $x=7, y=2$ nearest integers: upper $x-y$. **ANSWER: $7.5-1.5=6$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Rectangle 5.2×3.8 nearest0.1: upper area. **ANSWER: $5.25\times3.85=20.2125$**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Mass 2.4 kg nearest0.1,volume0.8 L nearest0.1: lower density. **ANSWER: $2.35/0.85=2.7647\ldots$ kg/L**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. Explain why quotient uses opposite endpoints. **ANSWER: large numerator/small denominator maximises**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

PRACTICE ANSWERS

CHAPTER 16

Answers, method guidance and repair notes

Higher Number modelling, proof and multi-stage reasoning

Attempt every question first. The answer confirms the outcome; the method guidance identifies the governing process. Rework an error from a blank line and show every algebraic or numerical stage.

1. Simplify $\sqrt{75}+\sqrt{12}$. **ANSWER: $7\sqrt{3}$**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

2. Rationalise $6/\sqrt{3}$. **ANSWER: $2\sqrt{3}$**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

3. Convert 0.1818… to fraction. **ANSWER: 2/11**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

4. $(4\times10^{5})(7\times10^{-3})$. **ANSWER: 2.8×10^{3}**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

5. £800 grows 6% for 4 years. **ANSWER: £1009.98**

Method guidance: Identify the mathematical structure before calculating. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

6. Smallest n making 90n a square. **ANSWER: 10**

Method guidance: Choose an exact, algebraic or numerical representation. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

7. Upper bound 6.2/1.8 both nearest0.1. **ANSWER: 6.25/1.75=25/7**

Method guidance: Carry out each transformation with a stated reason. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

8. State two checks on a multi-stage model. **ANSWER: units and magnitude/constraints/estimate**

Method guidance: Check restrictions, magnitude, accuracy and units. Apply the rule to the stated values, record each transformation, then verify sign, size, restrictions, accuracy and units.

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