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Westminster School 11+ Maths 2024

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02 Question Paper

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WESTMINSTER SCHOOL
THE CHALLENGE 2024

MATHEMATICS II

Tuesday 30 April 2024

Time allowed: 1 hour 30 minutes

You will need a calculator for this paper.

All your working should be clearly shown.

You should attempt all the questions.

Please write in black or blue ink.

Write your answers in the answer booklet provided.

- 1 a i Subtract $\frac{1}{2}x - 1$ from $\frac{1}{2}(x - 1)$ and simplify your answer.
 ii By what must you divide $28a$ to get $7a$?
- b Tom correctly solved a pair of simultaneous equations in his maths homework, but parts of the question and his answer have since been obscured by ink blots.

question:

Solve the simultaneous equations

$$\frac{5}{2}x - \frac{3}{4}y = \frac{8}{3}$$

$$x + \frac{1}{2}y = \frac{1}{12}$$

Tom's correct answer:

$$x = \frac{11}{12} \text{ and } y = \text{ink blot}$$

Find the numbers hiding under the ink blots.

- 2 The density of steel is 7.85 grams per cubic centimetre. Four thousand identical spherical steel ball bearings together weigh 1.4 kilograms. Find the radius of each ball bearing in millimetres.

[A sphere of radius r centimetres has volume $\frac{4}{3}\pi r^3$ cubic centimetres.]

- 3 In "old money", each pound was divided into 20 shillings and each shilling was divided into 12 pence.

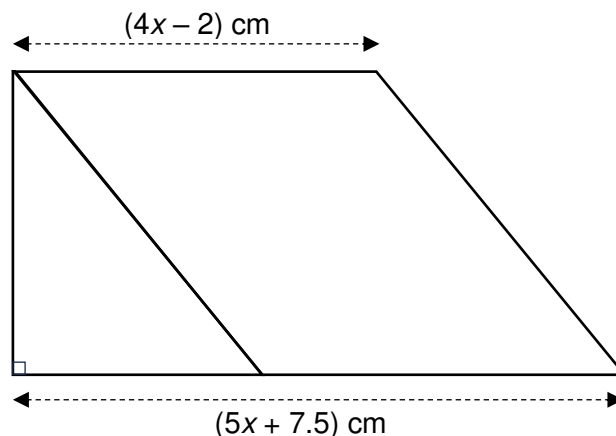
In February 1970, a jeweller sold one hundred gold bracelets. The first sixty-eight bracelets were sold at 1 pound, 7 shillings and 6 pence each, but the remainder were sold at a discounted price. His total takings for gold bracelets in February 1970 were 124 pounds and 6 shillings.

What percentage discount did the jeweller offer, and what was the discounted selling price (in pounds, shillings and pence)?

- 4 a Arif is 14 years old. His pocket money now is 48% greater than it was when he was 12. When he was 13, his pocket money was £19.20 per week, which was 28% greater than it was when he was 12. How much is it now?
- b Billy has a barrel full of chocolate drops. Each week, he eats $n\%$ of the chocolate drops remaining in the barrel at the start of that week. At the end of the seventh week, he finds that only 10% of the original quantity of chocolate drops is left. What is the value of n ?

- 5 Sequences of numbers are produced using the rule “*multiply by p , then subtract q* ”. For example, if $p = 2$, $q = 3$ and the first term is 6, then the sequence would begin
 6 9 15 27 51 99 etc.
- a If $p = 1.5$, $q = 0.5$ and the first term is 17, write out the first five terms.
- b If, instead, the sequence begins 20, 45, 170, ... , what are the values of p and q ?
- c If, instead, the fourth, fifth and sixth terms are 48, 142.5 and 426 respectively:
- i What is the first term?
- ii Explain why the 2024th term will be a whole number and find its last digit. Justify your answer briefly.

- 6 In the diagram, the large trapezium is made up of a right-angled triangle and a parallelogram. The area of the large trapezium is 338.1 cm^2 ; this area is divided between the right-angled triangle and the parallelogram in the ratio 7 : 16. Find the perimeter of the large trapezium.

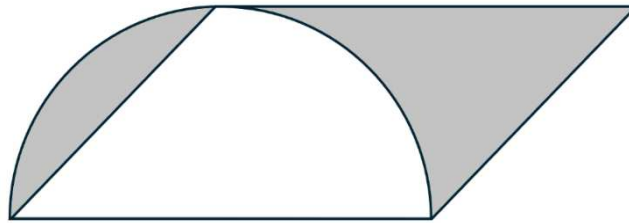


- 7 After a Scout Jamboree, 1003 Scouts travelled home by coach or minibus. Each coach carried 53 Scouts and each minibus carried 13 Scouts. There were x coaches and y minibuses. Find the possible pairs of values of x and y .
- 8 Mr Tiring walks to and from work on Mondays, Tuesdays and Wednesdays. On Tuesdays, his speed is two-thirds of his speed on Mondays. On Wednesdays, his speed is three-quarters of his speed on Tuesdays. On Thursdays and Fridays, feeling exhausted, he takes the bus along the same route that he walks. The bus travels at a speed of 7 miles per hour.

One quarter of Mr Tiring’s weekly commuting time is spent on the bus. How fast does he walk on Mondays?

TURN OVER

- 9 The logo in the diagram consists of an overlapping semicircle and parallelogram. To the nearest whole number, what percentage of the logo's area is shaded?



- 10 Andrew is solving a puzzle in a mathematical magazine. To complete the puzzle, he must fill in every cell of the grid below with one of the digits 1, 2, 3, 4 and 5, in such a way that the *Puzzle Property* is always true:

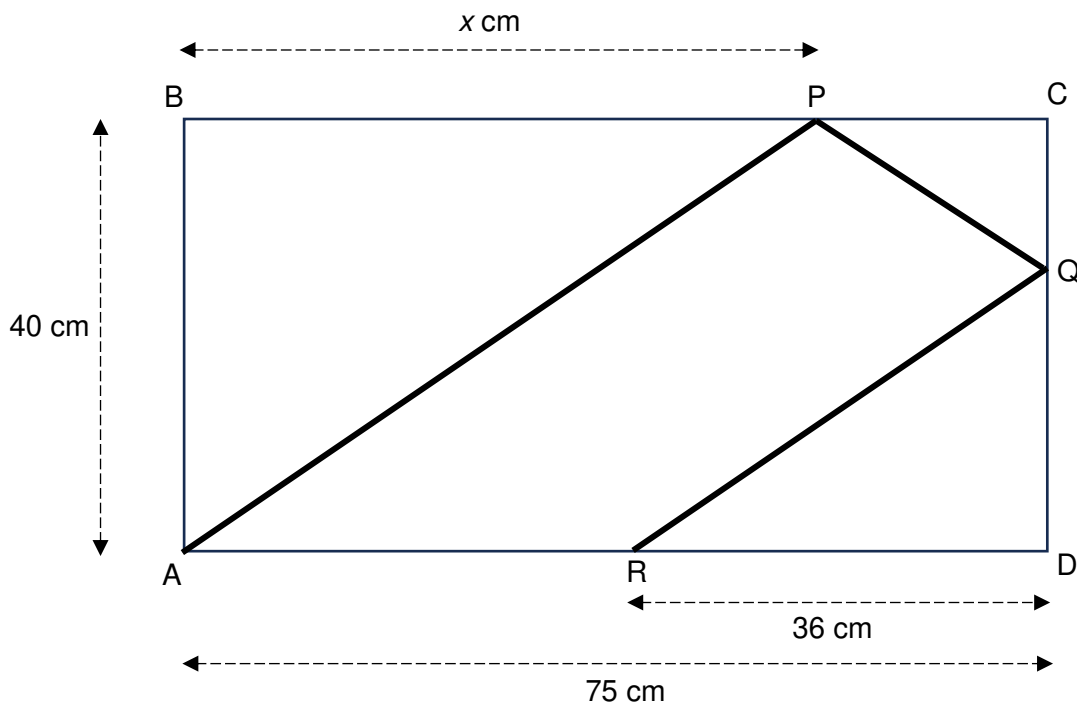
Puzzle Property: whenever digit d appears in column x , row y ,
 then digit x appears in column d , row y ,
 and also digit y appears in column x , row d .

The **bold** digits were given as part of the puzzle.

	col 1	col 2	col 3	col 4	col 5
row 1	2				
row 2					2
row 3			1		
row 4	5				1
row 5			5		

- a Andrew has used the *Puzzle Property* to write digit 1 in column 5, row 4. What digit can he write in column 1, row 5? What digits can he subsequently write in
- column 5, row 1
 - column 4, row 5
 - column 4, row 1 ?
- b Prove that the *Puzzle Property* forbids the same digit from appearing twice in any row or column.
- c Make a copy of the grid in your answer booklet and complete the puzzle.

- 11 A laser beam is fired from point A, which is at one corner of a rectangular mirror box ABCD. It reflects off the mirror walls at points P and Q, as shown by the heavy line in the diagram, before striking a receptor at R. Some lengths are shown on the diagram.



- i Explain why triangles ABP, QCP and QDR are all mathematically similar.
 ii Hence find x .
- 12 a The angles in an isosceles triangle are 45° , 45° and 90° , and the length of the equal sides is 1. What is the length of the remaining side?
- b Grace has two identical cardboard rectangles, which she overlaps to make the polygon shown in the left-hand diagram. She finds the area and perimeter of the polygon.



Later, Grace moves one of the rectangles so that it makes a 45° angle with the other, as shown in the right-hand diagram. Doing this reduces the perimeter of the polygon by 5 cm. By how much does it reduce the area?

END OF QUESTIONS

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Paper Notes: 11+ Maths Question Paper (11+ Maths Past Paper (2024))

Compiled by [SATs-Papers.co.uk](https://www.SATs-Papers.co.uk) to help you get the most from this paper.

Overview

This is **Westminster School's Mathematics II** paper from **The Challenge 2024**, sat on Tuesday 30 April 2024. Westminster School is one of London's most academically selective independent schools, and this paper forms part of their **11+ entrance examination** for Year 7 entry. The paper tests advanced mathematical reasoning, problem-solving skills, and algebraic fluency well beyond the standard primary curriculum.

The examination allows **90 minutes** and permits calculator use. Questions span a wide range of topics including algebra, geometry, sequences, percentage calculations, and logic puzzles. Many problems are multi-step and require candidates to synthesise different mathematical techniques within a single question. The paper is presented in a clear format with diagrams provided where necessary, and candidates write their answers in a separate booklet.

This paper is aimed at very able Year 6 pupils applying to Westminster School. The level of challenge is significantly higher than typical 11+ papers, reflecting Westminster's reputation for mathematical rigour. Questions often contain unfamiliar contexts or require candidates to prove statements, pushing beyond routine application of learned methods.

How this paper is organised

The paper comprises **12 major questions**, several of which contain multiple sub-parts. Question 1 begins with algebraic manipulation and simultaneous equations with obscured coefficients. Questions 2 through 4 explore applied problems involving density calculations, old currency systems, and compound percentage changes. Questions 5 through 8 cover sequences, geometric mensuration with ratios, Diophantine equations, and speed-time relationships.

Questions 9 through 12 form the most challenging section. Question 9 asks for an area calculation involving overlapping shapes. **Question 10** presents a logic puzzle requiring candidates to fill a 5×5 grid according to a complex symmetry rule, with sub-parts asking for proof that no digit can repeat in any row or column. Question 11 involves similar triangles in a laser reflection problem, whilst **Question 12** combines isosceles right triangles with a rotation problem about perimeter and area reduction.

Candidates are instructed to show all working clearly and attempt every question. The paper assumes strong algebraic facility, geometric reasoning, and comfort with formal mathematical argument. The absence of a published mark scheme in this document means candidates must rely on their teacher or tutor for feedback on their solutions.

Topics covered

- Algebraic manipulation: simplifying expressions involving fractions and subtraction of linear terms
- Simultaneous linear equations with fractional coefficients, including solving with missing constants
- Volume and density calculations using spheres; unit conversion between grams, kilograms, and millimetres
- Pre-decimal British currency arithmetic (pounds, shillings, and pence) with percentage discount problems
- Compound percentage changes over multiple stages; exponential decay calculations to find unknown percentage rates
- Linear recurrence sequences with multiplication and subtraction rules; finding unknown parameters and proving properties of terms
- Area and perimeter of composite shapes including trapezia, parallelograms, and right-angled triangles; using ratios to split areas
- Diophantine equations (linear equations in two integer variables); systematic solution finding with constraints
- Speed, distance, and time problems involving variable speeds and weighted averages
- Area calculations for overlapping semicircles and parallelograms; percentage of shaded regions
- Logic puzzles with formal properties; completing grids subject to symmetry constraints and proving uniqueness results
- Similar triangles in geometric configurations; angle reflection properties and proportional reasoning
- Isosceles right triangles and Pythagoras' theorem; geometric transformations involving rotation and their effects on perimeter and area

How to use this paper for revision

- Practise algebraic manipulation with fractions daily, ensuring you can expand, simplify, and factorise confidently without errors in sign or coefficient.
- Work through multi-step problems methodically, writing down every intermediate result. Westminster values clear working as much as the final answer.
- Familiarise yourself with pre-1971 British currency if you encounter historical problems: 1 pound equals 20 shillings, 1 shilling equals 12 pence.
- Strengthen your understanding of sequences by identifying patterns from multiple terms and expressing rules algebraically rather than relying on trial and error.
- Review similar triangles thoroughly, focusing on identifying corresponding sides and setting up correct proportions from diagrams.
- Attempt logic puzzles from mathematical magazines or online sources to build familiarity with formal reasoning and proof techniques.
- Time yourself on past papers under exam conditions, allocating roughly 7 to 8 minutes per question but being prepared to spend longer on the final multi-part problems.

Common mistakes to avoid

- Forgetting to subtract the constant term when applying the recurrence rule in sequence problems, leading to incorrect subsequent terms.
- Mixing up which sides correspond in similar triangles, particularly when diagrams show reflections or rotations.
- Losing track of units during density and volume calculations; failing to convert millimetres to centimetres or grams to kilograms consistently.
- Rushing into simultaneous equations without carefully identifying which coefficients are given and which need to be found.
- Misinterpreting the Puzzle Property in Question 10 by applying it in only one direction rather than checking all three required placements.
- Calculating percentage change incorrectly by adding or subtracting percentages arithmetically instead of using multiplication by factors like 1.28 or 1.48.

Exam technique

Start by reading the entire paper quickly to identify questions where you can make immediate progress. Questions 1a and 2 are relatively self-contained and can build confidence early. Allocate time proportionally: simpler questions deserve 5 to 7

minutes, whilst multi-part problems like Question 10 or 12 may require 12 to 15 minutes. If you become stuck, move on and return later rather than losing valuable time.

Show every step of your working, even for calculations you can do mentally.

Westminster markers award method marks generously, so a clear method with an arithmetic slip may still earn most of the credit. Use diagrams wherever helpful, particularly in geometry questions, and label all variables and points clearly. For proof questions like 10b, write your argument in full sentences explaining why each step follows logically from the previous one.

Leave time to check your answers, especially unit conversions and signs in algebraic expressions. In logic problems, verify that your completed grid satisfies all stated conditions. If a question asks for justification or explanation, a numerical answer alone will not suffice; you must demonstrate your reasoning. Practise writing concise mathematical arguments under timed conditions before the exam.

What to revise alongside this paper

To prepare fully for this paper, ensure you are confident with GCSE Foundation algebra, including solving equations with brackets, fractions, and multiple variables. Review circle theorems and properties of quadrilaterals beyond the Year 6 curriculum, as Westminster often expects familiarity with angle and symmetry properties taught in Year 7 or 8. Practise forming equations from worded problems, particularly those involving rates, percentages, and geometric relationships.

Beyond this paper, explore modular arithmetic and divisibility rules for number theory problems, which appear frequently in selective school entrance exams. Study techniques for proving general statements, such as proof by contradiction or exhaustion, since Westminster values formal reasoning. Work through Olympiad-style problems from sources like the UKMT Junior Mathematical Challenge to develop the creative problem-solving skills required for the later questions.

If you found this paper challenging, consolidate your understanding of ratio, proportion, and percentages using structured resources like advanced CGP or Bond books. For those who completed it comfortably, progress to UKMT Intermediate Challenge papers or explore A-level Pure Mathematics topics such as sequences and series, algebraic proof, and coordinate geometry to deepen your mathematical maturity.

Key terms

Simultaneous equations, Algebraic simplification, Volume of a sphere, Density, Compound percentage, Recurrence relation, Diophantine equation, Similar triangles, Trapezium, Parallelogram, Ratio, Proportional reasoning, Isosceles right triangle, Pythagoras' theorem, Mathematical proof

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WESTMINSTER SCHOOL
THE CHALLENGE 2024

MATHEMATICS III

Wednesday 1 May 2024

Time allowed: 1 hour 30 minutes

You may **not** use a calculator for this paper.

All your working should be clearly shown.

You should attempt all the questions.

Please write in black or blue ink.

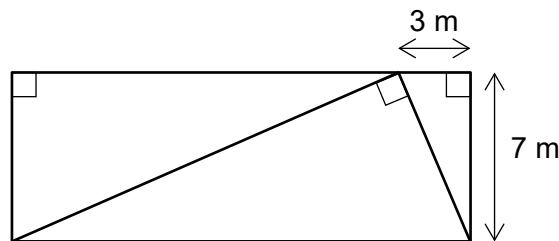
Write your answers in the answer booklet provided.

- 1 Solve the following simultaneous equations, giving your answers as mixed fractions.

$$2a + 5 = 5(a - b)$$

$$(2a + 5)(b - 4) = (a - 1)(2b + 1)$$

- 2 Twenty perforators can make 3885 pieces of confetti in 51 minutes.
How many perforators are needed to make 7511 pieces of confetti in 29 minutes?
- 3 A shop sells three sizes of orange juice bottle made by the Innocuous Juice Company: a 0.33 litre bottle costs £1.50, a 0.9 litre bottle costs £3 and a 1.35 litre bottle costs £4.
The 0.33 litre bottles have the special offer “*three for the price of two*” while the other bottles have no special offers.
If you have £50 to spend, what is the largest amount of orange juice that you can buy?
- 4 My pet mouse eats 10 g of peanut butter in 4 minutes 40 seconds, and he eats 10 g of chocolate in 3 minutes 20 seconds. For his birthday, I give him a meal of peanut butter with a side of chocolate. The meal has a total weight of 85 g and he eats it in exactly 36 minutes. How much peanut butter was in the mouse’s birthday meal?
- 5 The diagram below shows three right-angled triangles which form a rectangle. Find the area of the rectangle. Give your answer as a mixed fraction in square metres.



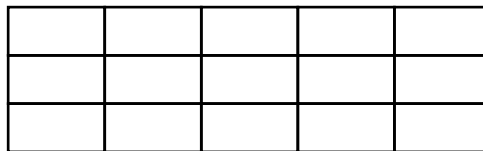
- 6 An indoor cycling track is a loop of length 250 m. Flotsam and Jetsam compete against each other in a ‘pursuit’ race. They begin simultaneously at exactly opposite points on the track, cycle anticlockwise around the track, and attempt to overtake their opponent. If this happens, the race ends. Alternatively, the race ends when the first competitor completes sixteen laps of the track, if neither has overtaken the other at that time.
Flotsam and Jetsam cycle at constant speeds of 46.2 km/h and 44.7 km/h respectively. How far does Flotsam cycle before winning the race?
- 7 a Expand and simplify the expression $(3x - 1)^2$.
b Hence, or otherwise, find $\sqrt{89401}$.

8 If 132 nuts and 693 bolts is 8.96 kg heavier than 512 nuts and 417 bolts, then how much heavier than 665 nuts is 483 bolts?

9 Mad Max drives a Mini Cooper which travels 39 miles per gallon of petrol consumed. His friend Mild-Mannered Mike drives a Mercedes which does 52 miles per gallon.

Max and Mike are at the same location in the desert. They want to travel together as far as they can, with both vehicles. Their petrol tanks are empty, but they have a can containing $3\frac{1}{2}$ gallons of petrol, which they can share. How far can they go?

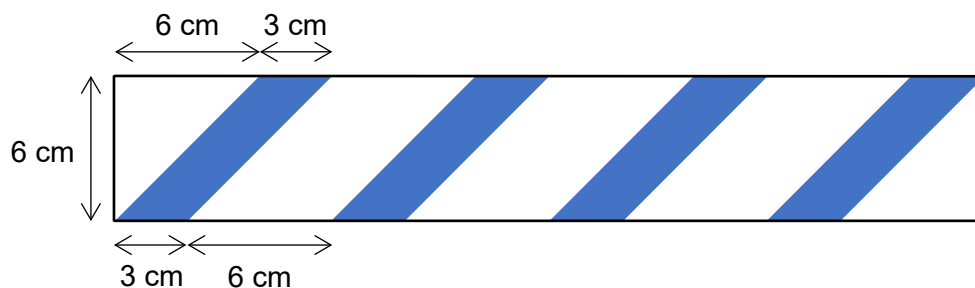
10 I am building a wall in my garden using standard cinder blocks which are 16 inches wide, 8 inches deep and 8 inches tall. Blocks are laid with their long edges horizontal and parallel to the face of the wall, and with higher blocks directly above lower blocks:



The wall will be used as a projector screen for a rectangular image whose ratio of width to height is 16:9. I have 100 cinder blocks. What is the area of the biggest image that I can project fully onto this wall?

11 35% of all snakes have pointy noses, and 61% of all snakes have pointy tails. Among snakes which have at least one pointy end, 28% are pointy at both ends. What percentage of all snakes are pointy at both ends?

12 The front side of tape for crime scenes is white with diagonal blue stripes in the shape of parallelograms, as shown below with shading representing blue ink. (The reverse side of the tape is plain white.) The tape is always cut with a straight line perpendicular to the edges of the tape.



- a Find the total blue area on a piece of tape which is 140 cm long.
- b Find the length of a piece of tape which contains 412 cm^2 of blue area.

END OF QUESTIONS

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Paper Notes: 11+ Maths Question Paper (11+ Maths Past Paper (2024))

Compiled by [SATs-Papers.co.uk](https://www.SATs-Papers.co.uk) to help you get the most from this paper.

Overview

This is **Westminster School's Mathematics III Challenge paper** from **1 May 2024**, designed for candidates sitting the school's **11+ entrance examination**. It is a rigorous, 90-minute non-calculator paper that assesses problem-solving fluency across a broad range of topics, including algebra, rates, optimisation, geometry, and probability. The paper comprises **twelve extended problems**, each requiring multi-step reasoning and careful working.

Questions are presented in a variety of contexts, from simultaneous equations and square-root extraction to real-world scenarios involving petrol-sharing journeys, cycling races, and value-for-money calculations. The problems reward careful reading, logical planning, and precision in arithmetic. Several questions ask for answers in specific forms, such as **mixed fractions** or exact distances, reinforcing the importance of following instructions.

This paper is aimed at highly able Year 6 students preparing for entry to competitive independent schools. It is challenging by design, with some questions demanding insight into rates of work, combined proportions, and geometric decomposition. Candidates should be comfortable manipulating fractions, working with units, and translating word problems into mathematical expressions.

How this paper is organised

The paper contains **twelve numbered questions**, with no explicit breakdown of marks but a clear expectation that **all working must be shown**. The paper is set for **1 hour 30 minutes**, so candidates have roughly seven to eight minutes per question on average, though some will be quicker and others will require more time. **No calculator is permitted**, and answers must be written in an answer booklet.

Questions are presented in order of increasing conceptual demand, though not strictly by difficulty. Early questions include simultaneous equations and rates of work, while later questions involve optimisation, set-theoretic reasoning with percentages, and geometric pattern-finding on crime-scene tape. **Question 5** includes a diagram of three right-angled triangles forming a rectangle, and **Question 10** features a sketch of cinder blocks arranged in rows.

Each question is self-contained, and candidates are advised to **attempt all questions**. Several questions specify the required form of the answer, such as mixed fractions in Question 1 or area in square inches in Question 10. The paper closes with a two-part question on area calculation and inverse reasoning, testing both direct computation and algebraic manipulation.

Topics covered

- Simultaneous linear equations with algebraic manipulation and solution as mixed fractions
- Rates of work and proportional reasoning involving multiple workers and time constraints
- Value-for-money optimisation with multi-tiered pricing and special offers
- Mixture problems and weighted averages involving rates of consumption over time
- Pythagorean theorem and area of composite geometric figures involving right-angled triangles
- Relative motion and pursuit problems on a circular track with constant speeds
- Expansion of binomial expressions and reverse-engineering square roots from expanded forms
- Simultaneous linear equations in two unknowns derived from weight comparisons
- Joint travel optimisation with shared resources and different rates of consumption
- Area maximisation under constraints with aspect ratio and discrete unit constraints
- Conditional probability and set-theoretic reasoning with percentages and overlapping categories
- Geometric pattern recognition, area calculation of repeating parallelograms, and inverse reasoning from total area

How to use this paper for revision

- Practise solving simultaneous equations by substitution and elimination, paying close attention to when the question asks for mixed fractions rather than decimals.
- Work through multi-step rate problems by setting up proportions carefully and checking units at each stage, especially when time is given in minutes and speeds in different units.
- For optimisation questions like the orange juice problem, list all feasible combinations systematically rather than guessing, and compare total quantities to find the maximum.
- When tackling mixture or weighted-average problems, convert all times to the same unit (seconds or minutes) and set up equations for total weight and total time.
- Review the Pythagorean theorem and practise decomposing complex shapes into simpler right-angled triangles, checking that your final answer is in the correct units and form.
- For relative-motion problems on circular tracks, calculate the closing speed and use it to find the time until one cyclist overtakes the other, then multiply by the winner's speed.
- Strengthen your confidence in expanding brackets and recognising perfect squares, as this skill underpins reverse-engineering tasks like finding square roots from expanded forms.

Common mistakes to avoid

- Forgetting to convert mixed fractions to improper fractions when solving simultaneous equations, leading to arithmetic errors in the final step.
- Mixing up the order of operations in proportional reasoning, such as multiplying when you should divide, especially when both the numerator and denominator change.
- Assuming the cheapest per-litre option is always best in optimisation problems without checking whether the special offer changes the effective price.
- Setting up mixture equations incorrectly by failing to account for the fact that total weight equals the sum of components, or confusing rate per unit with total time.
- Misidentifying which sides of a composite figure are perpendicular or parallel, resulting in incorrect applications of the Pythagorean theorem.
- Calculating the distance travelled by both cyclists separately in pursuit problems without recognising that you only need the winner's distance to answer the question.

Exam technique

Begin by reading the entire paper to identify which questions you find most approachable, but resist the temptation to skip around too much as the questions are ordered to build in complexity. Allocate roughly **seven minutes per question**, but be prepared to spend longer on multi-part or diagram-based problems. Show every step of your working, even for arithmetic, because partial credit often depends on clear reasoning.

For questions specifying a form of answer (mixed fractions, square metres, exact distances), circle or underline that instruction as soon as you read it to avoid losing marks for giving a decimal when a fraction is required. In rate and proportion problems, write down the units at every step to catch errors before they propagate. If a question involves a diagram, label all known lengths and angles directly on the diagram and use Pythagoras or area formulas methodically.

If you are stuck on a question after two or three minutes of thought, move on and return to it later with fresh eyes. The paper rewards careful planning more than speed, so double-check your final answers for unit consistency and whether they make sense in the context of the problem. Save a few minutes at the end to review your working and ensure you have answered what was actually asked.

What to revise alongside this paper

To prepare fully for this paper, ensure you are confident with **algebraic manipulation** including rearranging formulae, factorising, and solving systems of equations. Review **ratio and proportion** in depth, especially inverse proportion and combined rates of work. Practise converting between units of time, distance, and volume fluently.

Strong candidates should also revisit **Pythagoras in context**, including problems where you must identify which sides are adjacent or opposite, and **area decomposition** for irregular shapes. Explore **optimisation under constraints** by working through problems involving discrete choices, such as packing or purchasing scenarios. Finally, deepen your understanding of **set theory and Venn diagrams** as applied to probability and percentage problems with overlapping categories.

Once comfortable with this paper, progress to **GCSE Higher problem-solving questions** or other independent-school entrance papers to build stamina and confidence with unfamiliar contexts.

Key terms

Simultaneous equations, Mixed fractions, Rate of work, Proportional reasoning, Optimisation, Pythagorean theorem, Composite figure, Relative motion, Pursuit problem, Binomial expansion, Perfect square, Weighted average, Aspect ratio, Conditional probability, Area of parallelogram

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