

## 13+ PAST PAPER PACK

# Eton College 13+ Maths 2023

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# Eton College King's Scholarship Examination 2023

## MATHEMATICS A

(One and a half hours)

*Candidate Number:.....*

***Please write your candidate number on EVERY sheet.***

***Please answer on the paper in the spaces provided.***

*This paper is divided into two sections:*

*Section I (Short-answer questions) – 50 marks available*

*Section II (Extended questions) – 50 marks available*

*Answer all of Section I and as many questions as you can from Section II.*

*The marks for each part of each question are given in square brackets.*

*Show all your working.*

*No diagram is drawn to scale.*

***Neither calculators nor protractors may be used.***

***ADDITIONAL MATERIALS: NONE***

**Do not turn over until told to do so.**

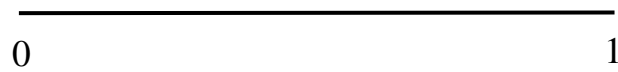
**Section I: Short-answer questions (50 marks)**

1) A fair, six-sided dice is thrown. Accurately illustrate, by using arrows and stating the letter, where the following events would be placed on the probability scale below.

**A:** A number less than 8 is thrown.

**B:** A '3' is thrown.

**C:** An even number is thrown.



[3]

2) A class consists of 10 students. Here are the test marks split by gender.

Girls:	5	3	10	2	7	3
Boys:	2	5	9	3		

a) Write down the modal mark of the class.

[1]

b) Work out the difference between the median mark of the girls and the median mark of the boys.

[2]

c) Work out the class mean mark.

[2]

3) Find the value of the following, giving your answers as **reduced, mixed fractions**.

a)  $3\frac{1}{6} + 1\frac{1}{4} \times 3\frac{3}{5}$

[3]

b)  $56\frac{11}{18} - 72\frac{7}{12}$

[3]

4) Find the value of the following, giving your answers as **decimals**.

a)  $0.037 \times 0.0078$

[3]

b)  $0.001311 \div 0.023$

[3]

5)

a) Fully simplify the following expressions.

i)  $\frac{9}{4}x - \frac{3x}{8}$

[1]

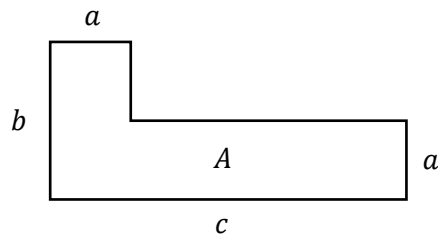
ii)  $\left(\frac{a^2}{b} \div \frac{b}{c}\right) \times \left(b^2 \div \frac{a}{c}\right)$

[2]

b) What do you need to subtract from  $7xy$  to get  $8yx$ ?

[1]

6)  
a)



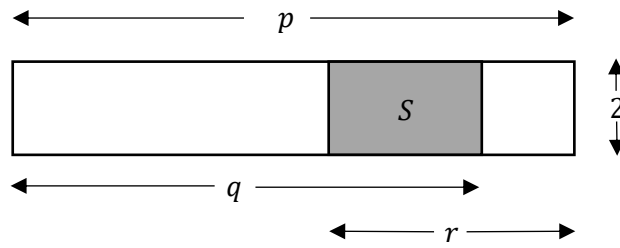
i) Find a **simplified** formula for the area,  $A$ , of this shape in terms of  $a$ ,  $b$  and  $c$ .

[2]

ii) Find the value of  $A$  when  $a = 0.5$ ,  $b = 3$  and  $c = 7$ , giving your answer as a **decimal**.

[2]

b)



- i) Find a formula for the area of the shaded part,  $S$ , in the diagram, in terms of  $p$ ,  $q$  and  $r$ .

[3]

- ii) Find the value of  $S$  when  $r = 8$ ,  $p = 12.1$  and  $q = \frac{41}{5}$ , giving your answer as a **decimal**.

[2]

7) Solve the following inequalities for  $x$ .

a)  $3 - 2x < \frac{1}{2}x - 2$

[3]

b)  $3x - 2(4 - x) < 6x + 7$

[3]

8) Solve the following equation for  $x$ . Give your answer as a **reduced, mixed fraction**.

$$\frac{2}{5}(3x - 1) = 4 - \frac{1}{2}(x - 2)$$

[3]

- 9) The mean of 7 different positive whole numbers is 7. What is the greatest possible value that any of these numbers could be?

[4]

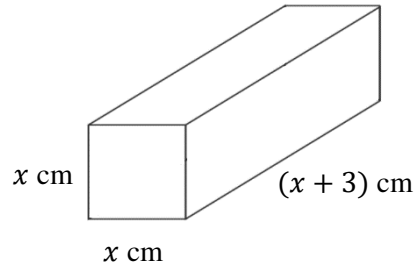
- 10) A robot is programmed to move 5 metres north, then 8 metres east, then 12 metres south, and finally 32 metres west. How far, in metres, is the robot now from the starting point?

[4]

**Section II: Extended questions (50 marks)**

11)

- a) A solid rectangular block measures  $x$  cm by  $x$  cm by  $(x + 3)$  cm.



- i) Draw a fully annotated net of the rectangular block.

- ii) How many vertices does the block have?

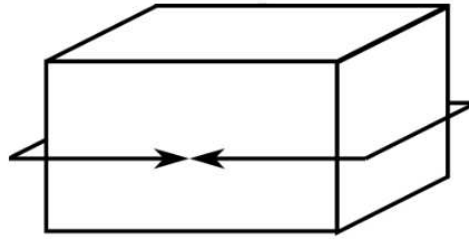
[2]

- iii) Find a simplified expression for the total surface area of the block in  $\text{cm}^2$ .

[1]

[3]

- b) The 'perimeter' of a cuboid can be measured along three axes. One 'perimeter' of this cuboid is shown. If the 'perimeters' of a cuboid are 16 cm, 20 cm and 28 cm, what is the volume of the cuboid?



[4]

12)

a) In this question, the symbol  $*$  is used to represent an operation on two numbers:  
 $x * y = x^y$ . For example,  $4 * 3 = 64$  and  $5 * 2 = 25$ .

i) Find the value of  $a$  given that  $a * 5 = 32$ .

[1]

ii) Calculate the value of  $(3 * 3) * 2$ .

[2]

b) The number 12345 can be expressed as the sum of two prime numbers in exactly one way. What is the larger of the two primes?

[1]

c) What is the smallest whole number you need to multiply 232 by to end up with a square number?

[3]

d) Prove that 46656 is a perfect cube.

[3]

13)

- a) Andy walks past a fruit stall on his way home. On Monday he purchased four apples and two oranges which cost £1.54. On Tuesday he purchased two oranges and four bananas which cost £1.70. How much would he pay if he were to buy one apple, one orange and one banana?

[3]

- b) The product of two numbers is equal to 24 less than the square of a third number. The first number is three more than the third, and the second is equal to the third. What is the sum of these three numbers?

[4]

c)  $W, X, Y$  and  $Z$  are positive single digit whole numbers. It is given that

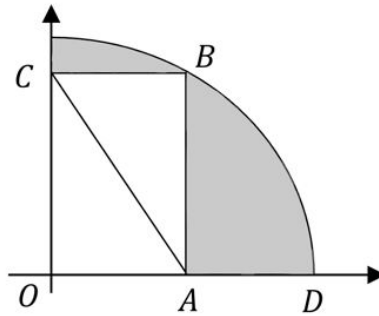
$$\begin{array}{r} 6 X 1 Z \\ - \\ W 2 Y 2 \\ \hline 3 3 3 3 \end{array}$$

Calculate the value of  $W + X + Y + Z$ .

[3]

14)

- a) A rectangle is inscribed in the quadrant of a circle centred at the origin,  $O$ , as shown.  
 $OA = AD = 5\text{cm}$ .



- i) Determine the exact length of the diagonal  $AC$ .

[1]

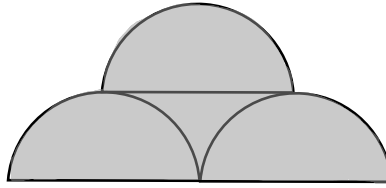
- ii) Show that the length  $AB$  can be written in the form  $\sqrt{x}$  where  $x$  is a whole number less than 100.

[2]

- iii) Using  $\frac{22}{7}$  as an approximation for  $\pi$ , and rounding  $\sqrt{x}$  to the nearest whole number, calculate an estimate for the shaded area to the nearest 5 square centimetres.

[4]

- b) The diagram shows three semicircles, each of radius 2 cm. Using  $\frac{22}{7}$  as an approximation for  $\pi$ , calculate an estimate of the shaded area, giving your answer **as a mixed fraction**.



[3]

15)

- a)  $x$  is a five-digit number which is a multiple of 45. The second, third and fourth digits are 5, 4 and 3, in that order. The first digit and the last digit are unknown. Find all possible values of  $x$ .

[3]

- b)  $y$  is a three-digit whole number. The sum of its digits is 25. Find all possible values of  $y$ .

[3]

- c) Show that the smallest positive whole number whose digits add up to 2023 can be written in the form  $a \times 10^b - c$  where  $b$  is an integer and  $a$  and  $c$  are integers less than 10.

[4]

**END OF PAPER**

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# Paper Notes: 13+ Maths Question Paper (13+ Maths Past Paper (2023))

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

## Overview

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This is the **King's Scholarship Examination in Mathematics A** for 2023, set by **Eton College** for candidates seeking admission at 13+. The paper tests a wide range of mathematical topics typical of Year 8 students preparing for highly selective independent schools, with an emphasis on rigorous problem-solving, algebraic manipulation, and geometric reasoning. The examination is designed to assess not only curriculum knowledge but also mathematical maturity and the ability to tackle unfamiliar or multi-step problems under timed conditions.

The paper is divided into two sections totalling **100 marks**. Section I presents **short-answer questions** covering fundamental topics such as probability, statistics, fractions, decimals, algebra, and inequalities. Section II offers **extended questions** requiring detailed reasoning and working, including problems on three-dimensional geometry, number theory, simultaneous equations, and area calculations involving circles and composite shapes. No calculators or protractors are permitted, reinforcing the focus on mental arithmetic, accurate algebraic technique, and logical reasoning.

This paper is ideal for students targeting King's Scholarships or high-level 13+ entrance exams at schools such as Eton, Westminster, or Winchester. It rewards clarity of working, precision in mathematical language, and the ability to synthesise multiple concepts within a single question. The format and difficulty make it an excellent benchmark for students preparing for competitive independent school entrance examinations.

## How this paper is organised

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The paper is organised into **two sections**, each worth 50 marks, and candidates have **one and a half hours** to complete the entire examination. Section I comprises **ten short-answer questions** (Questions 1 to 10), with individual parts typically worth 1 to 4 marks each. These questions test foundational skills in probability, measures of central tendency, fraction and decimal arithmetic, algebraic simplification, formula manipulation, inequalities, and logic problems. Each question is self-contained, and students are instructed to answer all of Section I.

Section II consists of **five extended questions** (Questions 11 to 15), each subdivided into multiple parts. These questions carry between 3 and 10 marks and demand more

elaborate reasoning, proof, or multi-step calculation. Topics include three-dimensional geometry, surface area and volume, custom operations, prime decomposition, simultaneous word problems, area of composite figures involving circles, and digit-sum problems. Students are encouraged to attempt as many questions as possible, with marks allocated to individual sub-parts.

All working must be shown, and diagrams are not drawn to scale. The rubric emphasises that clarity and rigour are essential, as partial credit is awarded for correct intermediate steps even if the final answer is incorrect.

## Topics covered

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- Probability on a scale: placing events corresponding to certain, impossible, and fractional probabilities on a 0 to 1 line
- Measures of central tendency: calculating mode, median, and mean from small data sets split by category
- Mixed-number arithmetic: addition, multiplication, and subtraction of mixed fractions with reduction to simplest form
- Decimal multiplication and division: handling products and quotients of decimals with multiple decimal places
- Algebraic simplification: combining like terms, simplifying quotients and products involving algebraic fractions
- Area formulae for composite shapes: deriving expressions for L-shaped figures and shaded regions involving rectangles
- Solving linear inequalities: manipulating inequalities with brackets, collecting terms, and expressing solution sets
- Solving linear equations with fractions: clearing denominators and isolating the variable to give mixed-number solutions
- Mean and range problems: using the mean to deduce constraints on a set of different positive integers and finding extremal values
- Coordinate geometry and distance: applying the distance formula or Pythagoras' theorem to movements on a grid or plane
- Three-dimensional geometry: drawing nets, counting vertices, calculating surface area and volume of cuboids and composite solids
- Custom operations: interpreting non-standard notation (e.g.  $x * y = x^y$ ) and evaluating nested expressions
- Prime factorisation and perfect powers: expressing numbers as products of primes, identifying perfect cubes, and finding square and cube roots
- Simultaneous word problems: setting up and solving systems of linear equations from real-world contexts (e.g. fruit prices)
- Area of sectors and composite circular figures: estimating areas using rational approximations for  $\pi$  and handling overlapping semicircles
- Digit-sum and divisibility rules: finding multi-digit numbers satisfying constraints on digit sums, multiples of 45, and minimal representations

## How to use this paper for revision

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- Practise fraction arithmetic without a calculator, focusing on finding common denominators quickly and reducing answers to their simplest form.
- Revise the divisibility rules for 3, 5, 9, and composite numbers like 45, as these underpin several number-theory questions in Section II.
- Strengthen your ability to manipulate algebraic fractions, including dividing by a fraction and simplifying products involving multiple variables.
- Work on setting up and solving simultaneous equations from word problems, labelling variables clearly and writing out each equation explicitly.
- Familiarise yourself with area formulae for composite shapes, including L-shapes, rectangles with cut-outs, and regions involving semicircles.
- Learn to express answers in the exact form requested (e.g. mixed fractions, decimals, surd form) and always reduce fractions fully.
- Practise drawing accurate nets for cuboids and labelling all dimensions, as this skill is tested explicitly in Section II.

## Common mistakes to avoid

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- Forgetting to reduce mixed fractions to their simplest form, resulting in loss of marks even when the numerical value is correct.
- Misapplying the order of operations when custom operations are defined, especially when nesting (e.g.  $(3 * 3) * 2$  requires two separate evaluations).
- Confusing the median with the mean, or failing to order data sets before identifying the median, particularly when data are split by category.
- Omitting working for multi-step problems in Section II; examiners award partial credit for correct intermediate steps, so all reasoning should be shown clearly.
- Incorrectly handling the sign when solving inequalities, especially when multiplying or dividing both sides by a negative coefficient.
- Miscalculating the area of composite shapes by failing to subtract the cut-out region or by using the wrong dimension for height or width.

## Exam technique

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Attempt all of **Section I** first, as these shorter questions are designed to be more accessible and allow you to accumulate marks quickly. Allocate roughly **40 to 45 minutes** to Section I, leaving the remainder for the extended questions in Section II. If

you become stuck on a sub-part in Section I, move on and return to it later; every mark counts, and spending too long on one question can cost you easier marks elsewhere.

In **Section II**, read each question carefully and identify what is being asked before you begin calculating. Write out all working clearly, labelling intermediate results and stating any formulae you use. Even if you cannot complete a question, partial credit is awarded for correct method, so show every step of your reasoning. If a question asks you to prove or show something, ensure your argument is logical and complete; stating the result without justification will not earn full marks.

Manage your time by checking how many marks each part is worth. A 1-mark question in Section I should take less than a minute, while a 4-mark extended question in Section II may require several minutes of careful algebra or geometry. Leave a few minutes at the end to review your answers, checking that all fractions are fully reduced, all units are correct, and that you have answered the precise question asked (for example, finding the sum of variables rather than listing them individually).

## What to revise alongside this paper

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Students working through this paper should also revise **quadratic factorisation** and solving simple quadratic equations, as these skills underpin more advanced 13+ syllabuses and are often tested in scholarship examinations. Strengthen your understanding of **ratio and proportion**, particularly in problem-solving contexts, as these topics frequently appear alongside simultaneous equations and real-world modelling questions.

Beyond the core topics tested here, familiarise yourself with **coordinate geometry** in two dimensions, including gradient, midpoint, and distance, as well as **transformations** (reflection, rotation, translation, and enlargement). These topics are standard at 13+ and often appear in extended questions requiring both algebraic and geometric reasoning.

For students aiming at King's Scholarships or similar awards, explore **proof techniques** (proof by exhaustion, contradiction, and direct proof), **sequences and series** (including arithmetic and geometric progressions), and **circle theorems** involving angles, tangents, and chords. These topics represent the next step in mathematical sophistication and are essential preparation for scholarship-level mathematics papers.

## Key terms

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**Probability, Mode, median, mean, Mixed fraction, Improper fraction, Common denominator, Algebraic simplification, Linear inequality, Simultaneous equations, Composite shape, Surface area, Volume of a cuboid, Prime factorisation, Perfect cube, Divisibility rule, Surd, Quadrant of a circle**

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# Eton College King's Scholarship Examination 2023

## MATHEMATICS B

(One and a half hours)

*Candidate number:*.....

**Please write your candidate number on EVERY sheet.**

**Please answer on the paper in the spaces provided.**

There are 8 questions: each one is worth 10 marks.

Calculators are allowed, but you should show all your working.

**Do not turn over until told to do so.**

Q1

(a) Simplify:

(i)  $x^{30} \times x^{10}$

(ii)  $(x^3)^{20}$

(iii)  $(x^3 y^4)^5$

(b) Let  $x = 18^2 \times 19^3 \times 20^4 \times 21^5$ (i) Find  $x$  as a product of powers of its prime factors.

- (ii) Find, as a product of powers of prime factors, the largest factor of  $x$  which is a square number.

- (iii) Find, as a product of powers of prime factors, the largest factor of  $x$  which is also a factor of  $y = 18^5 \times 19^4 \times 20^3 \times 21^2$

Q2

- (a) The Knave of Hearts has stolen some tarts and been apprehended in turn by three guards, one after the other. To bribe them, he gave to each in turn one half of the tarts he had on him at the time, and an extra two to sweeten the deal. In this way, he eventually managed to escape with one tart for himself. How many tarts had he originally stolen?

- (b) Four brothers go to different towns to sell boxes of figs: they sell 500 boxes in total. David goes to Doncaster and sells  $d$  boxes for £4 each. Edgar goes to Edgbaston and sells seven fewer boxes than David, but for £7 each. Frederick goes to Falmoth and sells three times as many boxes as Edgar but for only £5 each. Gregory goes to Godalming and sells the remaining boxes for £2 each.
- (i) Find, in terms of  $d$ , a simplified expression for the number of boxes that Gregory sells.

The total money collected by the brothers for selling the 500 boxes is £2150.

- (ii) By forming and solving an equation for  $d$ , find Gregory's total sale value.

Q3

- (a) 3.5% of pupils in a school hate mathematics. 80% of those that hate mathematics drink tea and 60% of those who don't hate mathematics drink tea. What percentage of tea drinkers hate mathematics? Give your answer to three significant figures.

- (b) Eton College has sprung a leak and rain water has already accumulated in the wine cellar. Schoolmasters are supplied with pumps to remove the water: all masters pump water at the same rate and never tire of their work whilst water remains in the wine cellar. However, rain is still coming in at a constant rate; the leak can only be plugged once the cellar is fully pumped dry. It is calculated that twelve masters could pump the cellar dry in 3 hours but if only five masters were available it would take 10 hours. However,  $x$  masters are free and they pump it dry in two hours. Find  $x$ .

Q4

Suppose that  $x$  is a number such that  $x^2 + 3x = -1$ . WITHOUT calculating the value of  $x$ , and showing your working carefully, find the **exact** value of:

(a)  $3x^2 + 9x$

(b)  $(x+1)(x+2)$

(c)  $x^3 + 3x^2 + x$

(d)  $x^3 + 3x^2 + x + 5$

(e)  $x^3 - 8x - 3$

(f)  $x^3 - 8x + 5$

(g)  $x^4 + 21x + 10$

(h)  $x(x+1)(x+2)(x+3)$

Q5

The Knave of Hearts has been sent to the shop to buy ingredients for the pantry. Three apples, two bananas and seven clementines cost 65p. Two apples and three clementines cost 5p more than two bananas. It is known that the price of each single fruit in pence is a positive integer.

- (a) Find the cost of:
- (i) one apple and two clementines (together);
  - (ii) two bananas and one clementine (together).

The Knave buys one of each of the three fruits. When he returns, he meets in turn the Duchess and the King; each privately asks him a question about his purchase:

D: Did you pay in total a multiple of 6p?

K: Did you pay in total more than 20p?

He answers each question truthfully, but the Duchess and the King remain unable to tell how much was paid for each individual fruit. They each meet the Queen and tell her their questions (but not the Knave's answers) and admit that they are still baffled. At this, the wily Queen announces that she knows the answer.

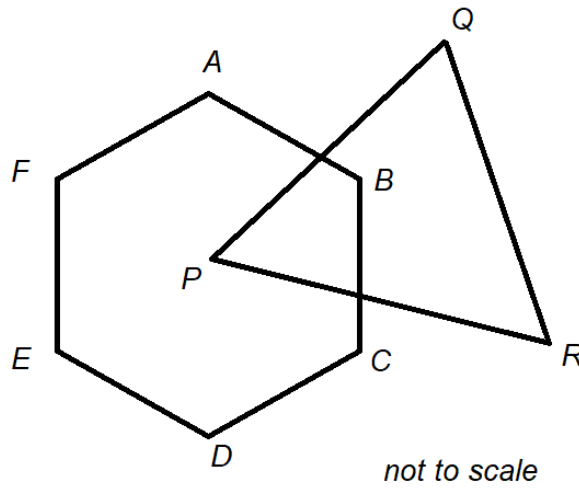
- (b) How much does the shop charge for each item of fruit? Explain briefly how you have deduced your answer.

Q6

- (a) A spherical ball is floating in a bath. More than half the ball is above the water level; the lowest point of the ball is 7cm below the water level. The points of contact between the surface of the water and the ball form a circle of diameter 30cm. Find, correct to three significant figures, the diameter of the ball.

- b) ABCDEF is a regular hexagon with centre P and PQR is an equilateral triangle. Suppose PQ intersects AB at S and PR intersects BC at T.

If  $AB = 3$ ,  $SB = 1$  and  $PQ = 6$ , determine the area of overlap of the two figures, giving your answer to three significant figures.



Q7

- (a) Three lorries — one red, one yellow and one green — are filled with bags of cement. Initially, the ratio of the numbers of bags in each lorry are in the ratio  
 $R : Y : G = 7 : 6 : 5$   
The foreman decides to move bags between lorries; after this, the number of bags are in the ratio  
 $R : Y : G = 6 : 5 : 4$
- (i) Which lorry gained the most bags?  
(ii) Which lorry lost the most bags?

The lorry that gained the most bags gained 12 bags.

- (iii) How many bags are there in total?

- (b) A carpenter, having a taste for oysters, is making a year's supply of mignonette sauce. He remembers it is made only of shallots and vinegar but cannot remember in what ratio, so he mixes a certain amount of both, but it has too little vinegar. He adds 9kg more vinegar to the mix, and finds the new mixture is one eighth shallot, but this is too little shallot. He then adds 1.2kg of shallots to the new mixture, and finds that the resulting mixture is five-sixths vinegar, and this is perfect.

What was the proportion of vinegar to shallots in the original mixture?



Point  $J$  lies on  $AG$  and point  $R$  lies on  $PQ$ . Points  $J$  and  $R$  are joined with a straight wire.  
 $JR$  is parallel to the side  $AE$ .

(b) Find the distance  $JR$ .

Point  $K$  lies on  $AG$  and point  $S$  lies on  $PQ$ . Points  $K$  and  $S$  are joined with a straight wire.  
 $KS$  is parallel to the side  $AD$ .

(c) Find the distance  $KS$ .

[END OF PAPER]

# Paper Notes: 13+ Maths Question Paper (13+ Maths Past Paper (2023))

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

## Overview

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This is the **Mathematics B** paper from **Eton College's King's Scholarship Examination 2023**, designed for candidates sitting the **13+ entrance exam** for entry into Year 9. The paper tests a wide range of mathematical skills, from algebraic manipulation and prime factorisation to geometry, ratio, and logic puzzles, all within **one and a half hours**. It comprises **8 questions**, each worth **10 marks**, and calculators are permitted, though working must be shown.

The paper demands both technical fluency and problem-solving ingenuity. Topics range from index laws and Diophantine-style equations to 3D geometry, conditional probability, and rates of work. The questions are worded in a narrative style (the Knave of Hearts, brothers selling figs, a flooded wine cellar), requiring candidates to translate real-world scenarios into precise mathematical models.

This paper suits high-achieving Year 8 pupils preparing for competitive scholarship exams. The difficulty level is significant, reflecting the selective nature of Eton's King's Scholarship cohort. Candidates should be comfortable with GCSE-level algebraic techniques, advanced geometric reasoning, and logical deduction under timed conditions.

## How this paper is organised

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The paper is organised as **8 equally weighted questions**, each worth **10 marks**, for a total of **80 marks**. Candidates have **90 minutes** to complete the paper and must write their candidate number on every sheet. Answers are to be written in the spaces provided on the question paper itself.

Question 1 opens with index laws and prime factorisation. Question 2 presents two multi-step word problems (a tart-sharing puzzle and an algebraic sales scenario). Question 3 covers conditional probability and a rates-of-work problem involving pumping water. Question 4 is an extended algebraic reasoning task built around a single constraint ( $x^2 + 3x = -1$ ), with eight parts requiring manipulation without solving for  $x$  explicitly.

Questions 5 through 8 maintain the narrative style: Q5 involves simultaneous equations with fruit prices and logic puzzles; Q6 combines 3D geometry (a floating sphere) and plane geometry (overlapping hexagon and triangle); Q7 tests ratio and mixture

problems; Q8 explores 3D coordinate geometry in a cuboid, requiring sketch plans and distance calculations for wires parallel to edges.

## Topics covered

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- Index laws: simplification of expressions involving powers, including products, powers of powers, and products of variables with exponents
- Prime factorisation: expressing large composite numbers as products of prime powers and identifying largest square factors and highest common factors
- Algebraic word problems: translating multi-step narrative scenarios (sharing tarts, selling boxes) into equations and solving for unknowns
- Simultaneous equations and inequalities: forming and solving systems in two or three variables, often with integer constraints
- Conditional probability and Bayes' theorem: calculating probabilities of events given other events, such as the proportion of tea drinkers who hate maths
- Rates of work and inverse proportion: modelling situations where multiple agents work at constant rates, with water inflow complicating the problem
- Algebraic manipulation without explicit solution: using substitution and factorisation to evaluate expressions when  $x^2 + 3x = -1$ , including cubic and quartic forms
- Logic puzzles and deductive reasoning: determining unique solutions from partial information and the knowledge that certain parties remain baffled
- 3D geometry and Pythagoras' theorem: finding the diameter of a sphere from the radius of a circular cross-section and depth below water level
- Plane geometry with regular polygons: calculating the area of overlap between a regular hexagon and an equilateral triangle using trigonometry and coordinate methods
- Ratio and mixture problems: tracking changes in ratios when quantities are added or removed, and solving for original proportions
- Cuboid geometry and spatial reasoning: sketching plan and elevation views, and calculating distances between points on diagonals and edges using 3D Pythagoras

## How to use this paper for revision

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- Practise index laws until they are automatic: every manipulation in Q1 must be fluent so you can tackle the algebraic reasoning in Q4 without hesitation.
- Master prime factorisation by hand for numbers up to about 1000, and learn to spot highest common factors and largest square factors quickly.
- Work through multi-step word problems slowly, defining variables clearly and writing down every equation before attempting to solve.
- For conditional probability, sketch a tree diagram or frequency table to visualise the given information and avoid sign errors.
- In algebraic manipulation tasks like Q4, substitute the constraint ( $x^2 + 3x = -1$ ) repeatedly rather than solving for  $x$ ; treat it as an identity.
- Draw clear, labelled diagrams for every geometry question, marking given lengths, angles, and parallel lines before attempting calculations.
- Time yourself on past papers: with only 90 minutes for 8 questions, you have roughly 11 minutes per question, so identify quicker marks early and leave harder parts until the end.

## Common mistakes to avoid

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- Forgetting to show working when calculators are allowed: the rubric explicitly requires all steps, so stating an answer without derivation loses marks.
- Misapplying index laws, especially  $(x^3)^4$  versus  $x^3 \cdot x^4$ : confusing the power-of-a-power rule with the product rule is a frequent error under time pressure.
- In word problems, failing to define variables clearly or skipping the equation-forming step, leading to arithmetic without algebraic justification.
- In Q4, attempting to solve  $x^2 + 3x = -1$  using the quadratic formula instead of using the constraint directly; the question explicitly prohibits calculating  $x$ .
- Overlooking integer constraints in Q5: the prices must be positive integers, so trial-and-error or modular arithmetic may be needed to narrow solutions.
- In 3D geometry, confusing plan and elevation views: plan view looks down onto the top face, elevation looks horizontally at a side face; mislabelling loses marks.
- Rushing through ratio problems without checking that the total quantity remains constant: in Q7, the total number of bags is fixed at all times.

## Exam technique

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Start by reading the entire paper in the first two minutes to identify the quickest marks and the longest multi-part questions. Tackle Q1 first to build confidence with index laws, then move to Q2 if you are strong on word problems, or skip to Q6 if geometry is your strength. Allocate roughly **11 minutes per question**, but be flexible: Q4 has eight parts and may take longer, so compensate by moving faster through Q1 or Q2.

Show every step of working, even when using a calculator. The rubric states "you should show all your working", which means marks are awarded for method as well as final answers. Write equations before solving them, label diagrams clearly, and define variables in word problems. If you are stuck on a multi-part question, attempt the earlier parts even if the later parts seem impenetrable; partial credit is generous in scholarship papers.

Leave time to check your answers. In the final five minutes, revisit any numerical answers for arithmetic errors, ensure units are consistent (e.g. cm vs m), and verify that your answers make sense in context (e.g. the Knave cannot have stolen a negative number of tarts). If you finish early, use the time to attempt parts you skipped rather than sitting idle; every mark counts in a competitive scholarship cohort.

## What to revise alongside this paper

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Students should revise **quadratic equations** (factorising, completing the square, and the quadratic formula) to handle algebraic constraints like  $x^2 + 3x = -1$  with confidence. **Trigonometry in right-angled triangles** (sine, cosine, tangent) is essential for Q6's hexagon-triangle overlap, as is the **area formula for regular polygons**. **Simultaneous equations in three variables** and **elimination methods** underpin Q5's fruit-pricing puzzle.

For 3D geometry, practise **Pythagoras' theorem in three dimensions** and **vector methods** for finding distances between points in space. **Mixture and ratio problems** (Q7) require fluency with **proportional reasoning** and **algebraic fractions**. Finally, revise **logical deduction puzzles** (often found in UKMT Intermediate and Senior Challenges) to build the reasoning skills needed for Q5's Duchess-King-Queen scenario.

Once comfortable with this paper, progress to **GCSE Higher Tier past papers** (especially Edexcel and OCR) for similar multi-step problems, and explore **STEP I foundation questions** for a taste of university-level proof and problem-solving at a comparable difficulty.

## Key terms

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**Index laws, Prime factorisation, Simultaneous equations, Conditional probability, Inverse proportion, Rates of work, Algebraic substitution, Pythagoras' theorem in 3D, Regular hexagon, Equilateral triangle, Plan view and elevation, Diophantine equation, Highest common factor, Perfect square factor, Cuboid geometry**

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