

MATHEMATICS SYLLABUS D

Paper 4024/11 Non-Calculator

Key messages

To do well in this paper, candidates need to

- be familiar with all the content on the syllabus
- be confident carrying out calculations without a calculator
- understand and use mathematical terminology
- draw accurate diagrams and graphs and read information from them
- solve problems using their mathematical knowledge
- show their working in clear steps.

General comments

Overall, candidates were able to access the paper successfully, and most attempted all questions. Many demonstrated secure knowledge across a range of topics and showed familiarity with the key concepts required. The paper offered an appropriate level of challenge for the strongest candidates while including questions that were accessible to candidates of all abilities.

Some areas proved more demanding, particularly questions involving vectors, composite functions, fractional indices, graphical solutions, speed–time graphs, volumes of similar shapes, recurring decimals and angle properties. Problem-solving questions were especially challenging, even for candidates who understood the underlying concepts, highlighting the need for stronger reasoning and application skills. Greater familiarity with angle terminology – such as alternate, corresponding, and co-interior – would support clearer reasoning and more accurate explanations.

Basic arithmetic skills were generally sound, although occasional slips were noted. Algebraic skills were strong overall, but errors were common when the unknown appeared in the denominator of an expression.

Most candidates presented their working clearly, with answers stated on the answer line. It is important that, when multiple methods are attempted, any rejected approaches are clearly crossed out so the intended solution is evident. Where candidates continue working for a question in a different space, this should be clearly indicated to avoid confusion.

Comments on specific questions

Question 1

The majority of candidates understood that the reciprocal of a fraction is the inverse. The most common incorrect approach was to calculate $7 \div 2$.

Question 2

- (a) Almost all candidates correctly established the mode as 2. A few candidates found the median instead.
- (b) Most candidates knew that the probability would be a fraction with a denominator of 9, and many candidates correctly evaluated the required probability. The most common incorrect approach was to include the child who watched 6 hours of television, giving a probability of $\frac{5}{9}$.

Question 3

Many candidates were able to calculate the new cost correctly. The most common strategy was to find 15 per cent and then subtract it from the original amount. Some candidates correctly found 15 per cent and then gave this as the answer. A few candidates went straight to finding 85 per cent of the original value, which was usually a successful strategy.

Question 4

- (a) For many candidates, both parts of this question presented some challenges. Many candidates were able to correctly find the angle of 68° in this part but were less confident with their reasoning. Some candidates who gave multiple reasons for their answer.
- (b) In general, candidates who were successful in the first part of the question were also successful here. Some candidates correctly established that the answer to **part (b)** was equal to **part (a)** and so gained the follow through mark. Some candidates referred to F angles in their reasoning rather than using the correct angle terminology, corresponding, so were unable to gain credit for stating a correct reason.

Question 5

- (a) The most common approach to this question was to calculate the angle for bus as $\frac{1}{4}$ of the angle for cycle and then use angles summing to 360° to find the remaining angle. Many candidates were also able to calculate the number of people who used a car, although this was not attempted by all.
- (b) The majority of candidates who had the correct angles in **part (a)** were able to draw their pie chart correctly. Some candidates were able to draw the given angle even though they had not found the missing angles in **part (a)**.

Question 6

Candidates who correctly understood the information given in the question were able to work out the mass of chocolate correctly. However, several candidates misinterpreted the questions and instead calculated $\frac{5}{7}$ of 350, arriving at an incorrect answer of 250.

Question 7

Most candidates were able to work with the cost per day to reach a value of \$270, which was the total cost associated with kilometres travelled. Many candidates attempted to do the correct division but found it difficult dealing with division by a decimal value.

Question 8

- (a) Most candidates were able to identify the transformation as a reflection. Some candidates did not give a line of reflection. The most common incorrect line was $y = 1$. A small number of candidates gave multiple transformations and so gained no credit.
- (b) Many candidates drew a triangle in the correct orientation following the rotation of 180° specified, but some had not used the given centre of rotation and so the placement of their triangle was incorrect. A small number of candidates rotated by 90° or 270° .

Question 9

Most candidates correctly rounded at least two of the values given in the calculation. Most of these candidates showed the values 100, 9 and 30 and were able to correctly obtain the answer of 3. Some candidates rounded 8.7 to 10, showing a misconception about the term 1 significant figure. A small number of candidates incorrectly evaluated the calculation with rounded values, most commonly obtaining an answer of 30 instead of 3.

Question 10

Almost all candidates answered this question correctly and obtained the answer of 36π . Some candidates used numerical values for π , for example 3.14 or $\frac{22}{7}$, and so were only able to gain partial credit. A small number of candidates incorrectly used 12 cm as the radius.

Question 11

Many candidates did not understand how to work with a given mean to find the total mass of plums. Those candidates that correctly obtained the values 300 g and 160g were typically then able to complete the question to find the mean of all 10 plums as 46g. Some candidates gained partial credit for finding either the value 300g or 160g. The most common incorrect approach was to sum 50g and 40g and then state that the mean of all 10 plums was 90g.

Question 12

Most candidates were able to correctly find the volume of the container as 720 cm^3 . Many candidates understood they needed to divide this value by the rate at which the water dripped. In many cases there was a misunderstanding around the units involved and candidates multiplied their 720 by various powers of 10. Many candidates gained partial credit for answers with figures 12.

Question 13

Most candidates were able to correctly add these fractions together. The most successful approach was to turn both mixed numbers into improper fractions, add them and convert the answer back into a mixed number at the end. Some candidates left their answer as $\frac{77}{12}$, for which they gained partial credit.

Question 14

- (a) A significant number of candidates did not use the graph to find the value of v in this question. Candidates assumed that the speed was constant through the motion and so used speed = distance $\div$ time to try and evaluate $800 \div 105$. Where candidates attempted to use the given speed-time graph they were generally more successful. The most successful method was to add the area of the triangle from $t = 0$ to 10 and then the rectangle from $t = 10$ to 105 and equate it to the given distance of 800m. A few candidates used the area of a trapezium successfully.
- (b) Candidates were more successful in this part than in **part (a)** showing that they understood that the acceleration was their speed $\div$ 10, with most candidates who attempted this part gaining credit.

Question 15

- (a) This question was correctly answered by the majority of candidates. The most common error was not reading the value from the graph correctly having drawn the correct line on.
- (b) Many candidates showed a good understanding of how to do this question correctly, finding that there were 23 journeys of 20 minutes or less and then subtracting this from the total number of journeys. Some candidates did not realise that their value of 23 was not the answer they were looking for and gave this as the final answer. Some candidates misread the scale of the graph and therefore worked with an incorrect value.

Question 16

- (a) Many candidates correctly found the value of angle QRT in this part. Candidates understood the geometric rule that they had used but a number of candidates referred to it as the 'bow-tie' rule which did not gain credit.
- (b) Candidates who correctly identified QTS as an angle in a semicircle and hence 90° generally went on to calculate TQS correctly. The most common incorrect answer was 32° , where candidates assumed triangle QST was isosceles

- (c) Candidates found this question challenging, with few able to correctly find the value of TVQ and many not attempting it. Candidates who were able to find the value of QTV as 32° were usually then able to correctly obtain the required angle.

Question 17

- (a) Where candidates identified that they needed to use Pythagoras' Theorem to find the height of the prism, they were then typically able to show a correct method to find the volume of the prism. A large number of candidates worked backwards from the given answer to show that the height must be 12 and then used this value of 12 to calculate the volume. This method did not gain any credit. The most successful candidates clearly showed the height of 12 cm was obtained using Pythagoras' Theorem, $\sqrt{13^2 - 5^2}$, then found the area of the front facing triangle using $\frac{1}{2} \times 10 \times 12 = 60 \text{ cm}^2$. Finally, they found the volume by calculating $60 \times 3 = 180 \text{ cm}^3$. A minority of candidates correctly found the height of the triangle but then were unable to use it correctly to find the volume.
- (b) A number of candidates did not attempt this question and those that did found it very challenging. Candidates seemed unfamiliar with the concept of volume scale factor and were unclear how to approach finding an answer. Successful candidates found the volume scale factor as 8 by dividing the given volumes and then found the linear scale factor as 2 by taking the cube root of this value. They then correctly multiplied this scale factor of 2 by the given base of 10 cm to obtain the correct answer, 20 cm.

Question 18

Many candidates were unfamiliar with the process for writing a recurring decimal as a fraction. A number of candidates were also unfamiliar with the notation for recurring decimals, incorrectly assuming that the recurring decimal was 0.141414 ... The most common incorrect answer was $\frac{14}{100}$ which was found by not using the fact the decimal was recurring. A small number of candidates understood the process and notation and were able to correctly obtain the answer.

Question 19

On the whole candidates were familiar with functions but were unclear how to work with composite functions. Many candidates simply multiplied the two expressions together, obtaining a quadratic equation that they could not solve. Some candidates were familiar with how to deal with composite functions but many of these candidates dealt with the functions in the wrong order, so obtained an incorrect expression. The candidates who correctly dealt with the two functions were usually able to methodically obtain the correct answer.

Question 20

Many candidates understood that they needed to find a common denominator to answer this question. Most candidates used a common denominator of $(2x)(7x)$ and so obtained a single fraction $\frac{27x}{14x^2}$. Some did not simplify this to gain full credit.

Question 21

- (a) Many candidates were familiar with indices but found it hard to apply the negative and fractional powers together. Some candidates were able to deal with the negative power and reached $\frac{1}{27^{\frac{2}{3}}}$.
- Other candidates dealt with the $\frac{2}{3}$ power but did not deal with the negative and so obtained an answer of 9 for partial credit. The most successful candidates dealt with the negative power first

and rewrote the fractional power using roots as $\frac{1}{(\sqrt[3]{27})^2}$ then obtained $\frac{1}{3^2}$ before reaching the correct final answer.

- (b) Many candidates were able to gain partial credit on this question. Some candidates correctly dealt with the power of x by multiplying the powers together. A few candidates spotted that the power of $\left(\frac{1}{100}\right)^{\frac{1}{2}}$ was equivalent to $\sqrt{\frac{1}{100}}$ and therefore evaluated to $\frac{1}{10}$. The most common incorrect answer here was to have the coefficient of x as $\frac{1}{50}$, the same as the power. Most errors occurred due to incorrectly dealing with the fractional coefficient.

Question 22

- (a) Most candidates were able to correctly obtain the y -value when $x = 2$ but had more difficulty when the x value was negative, cubing -2 incorrectly.
- (b) Most candidates correctly plotted their points from **part (a)** in this part. The majority of candidates knew that the points should be joined with a curve and not straight lines.
- (c) Candidates found this question very challenging. Many were unfamiliar with how to approach finding the appropriate line to draw. The most common incorrect line drawn was $y = 1$. Candidates who were able to subtract the equation in **part (a)** from the one in this part to find the line $y = 4x + 1$ were then usually able to successfully draw this line and find the solutions.

Question 23

- (a) Most candidates understood that they needed to manipulate the surds to obtain a single term. The most successful candidates wrote $\sqrt{8} \times \sqrt{6}$ as $\sqrt{48}$ which they were then able to write as $4\sqrt{3}$. At this point, some candidates forgot to add on the $\sqrt{3}$ from the original question. This meant they only gained partial credit for their solution.
- (b) Many candidates who tackled this question understood that they needed to multiply the numerator and denominator of the original fraction by $(2 + \sqrt{5})$. Candidates who wrote this out as a fraction multiplication generally obtained a correct value on both the numerator and denominator. Candidates who were most successful were able to correctly deal with the division by -1 which was required after the multiplication. The most common errors occurred when candidates only changed the sign of one of the numerator terms and not both.

Question 24

- (a) Candidates who substituted the known values of 30 and x into the formula for the area of a rectangle generally then obtained the correct expression for the width. Some candidates incorrectly obtained an answer of $x + 30$.
- (b) Candidates found this part very challenging, with very few able to correctly show the working leading to the given quadratic equation. Few candidates equated correct expressions for the perimeter of both the rectangle and triangle and were then able to manipulate the algebra to obtain the quadratic. Candidates who were able to correctly deal with the x term on the denominator of the rectangle perimeter were generally the most successful here.
- (c) Candidates were able to answer this part more successfully. The most successful candidates were able to factorise the quadratic and then obtain the two solutions. Some candidates attempted to use the quadratic formula. In some cases, this was used incorrectly, particularly as the coefficient of b was negative, which led to incorrect solutions. A small minority of candidates attempted a solution by completing the square, which whilst usually correct, was not the most straightforward solution. Some candidates had sign errors in their factorised expression.

- (d) Some candidates who had obtained a positive value for x in the previous part were able to obtain the perimeter of the rectangle in this part. Some candidates did not realise that their expression in **part (b)** was actually the perimeter of the rectangle and that the perimeter of the triangle was equal to it. It was clear that some candidates did not know how to use the value they had obtained in the previous part.

Question 25

A partial factorisation for partial credit was the most common response to this question, with many candidates not realising that once they had a factor of x they then had a quadratic expression to factorise. The most common answers were $x(6x^2 + 5x - 4)$ or $(3x^2 + 4x)(2x - 1)$ or $(3x + 4)(2x^2 - x)$.

Question 26

- (a) Many candidates were successful in this part of the question, showing an understanding of vector routes.
- (b) Candidates found this question very challenging. Many were unfamiliar with the term position vector. Some candidates were able to find $\overrightarrow{AT}$ or $\overrightarrow{BT}$ correctly. Some vectors identified in the working had incorrect notation, for example $\overrightarrow{BT}$ or just T instead of $\overrightarrow{TB}$. The most successful candidates gave a complete vector route for $\overrightarrow{OT}$ and then substituted in the vectors they had found.
- (c) Very few candidates were successful in this part even though the vector they needed to use was given in **part (b)**. Candidates were unfamiliar with manipulating vectors that were between points on a line and not a vertex. Candidates who gained partial credit in this part were able to give a correct vector route for $\overrightarrow{OQ}$ or $\overrightarrow{QB}$ or a correct vector in terms of a and b for either $\overrightarrow{OQ}$ or $\overrightarrow{QB}$.

MATHEMATICS SYLLABUS D

Paper 4024/12 Non-Calculator

Key messages

To do well in this paper, candidates need to

- be familiar with the whole syllabus, including all the new content
- select appropriate formulas and apply them correctly
- carry out basic calculations without a calculator
- understand and use correct mathematical terminology and notation
- draw accurate graphs and diagrams
- set out their work in clear, logical steps.

General comments

The paper discriminated between candidates of different abilities, with some questions accessible by all and others that offered challenge to the strongest candidates. In general, candidates were well prepared for questions requiring direct application of mathematical processes in familiar contexts. They had more difficulty accessing questions that required application of knowledge to solve a problem, such as **Questions 18 and 22**. Candidates appeared familiar with some of the new syllabus content such as surds but were less confident in the use of composite functions.

Candidates should read each question carefully and ensure that they follow instructions, such as to give an answer as a fraction in its simplest form, in terms of π , or as a surd in its simplest form. When a question specifies that a particular method be used, such as factorising to solve a quadratic equation, credit is not given for using a different method.

Some candidates demonstrated a solid grasp of basic arithmetic, although arithmetic errors were common in simple calculations such as $82 - 60$ or $1 - 7$. When calculating with fractions, candidates are advised to simplify first to avoid the need for complex multiplications. Candidates are reminded of the importance of reviewing their work carefully to minimise avoidable mistakes, such as arithmetic errors, sign errors and transcription errors.

Most candidates were competent with basic algebra. Many candidates found it difficult to manipulate expressions involving indices and were unable to construct and simplify quadratic equations. Candidates were usually able to plot points accurately and draw accurate diagrams. Candidates are reminded that lines should be drawn using a ruler and that curves should be drawn freehand.

Candidates should be familiar with the geometrical properties of shapes and be able to use these in a variety of problems. They should be able to give clear explanations and state circle theorems precisely when giving reasons.

Many candidates presented their work clearly and methodically, enabling the award of partial credit where appropriate.

Comments on specific questions

Question 1

- (a) Many candidates found the correct frequency for each colour. Some candidates left the tally column blank or used a tallying method other than the expected 5-bar gate notation. A significant minority of candidates were unsure how to complete the table and wrote the frequencies in the tally column and either cumulative frequencies, relative frequencies such as $\frac{5}{24}$, or other values such as $\frac{24}{5}$ in the frequency column. Some candidates made an error in one or more of the frequencies and a simple addition of their frequencies to check that the sum was 24 would have helped them to identify this error. Candidates should take care to read the headings of any tables and ensure that they write values in the correct cells.
- (b) This part was well answered using either the correct frequencies or the values from their frequency column, and most bar charts used accurate, ruled lines. The question asked for a bar chart, so a frequency polygon could only gain partial credit for a correct scale. Some candidates did not add a scale to the frequency axis, and a small minority used a non-linear scale. Some candidates chose a difficult scale, such as one square to represent three units, which made it difficult to draw the heights accurately. In some cases, the widths of the bars or the gaps between the bars were unequal.

Question 2

- (a) This question was answered well. A common incorrect answer was 0.76, the result of incorrect use of place value for 0.2 in the subtraction.
- (b) This question was also answered well. The most common incorrect answer was -40 , the result of incorrect application of the rule for multiplication of negative numbers.

Question 3

This question required candidates to apply the basic angle properties of triangles and parallelograms. Many candidates used these properties correctly, wrote the angles they had found on the diagram and found the correct value of x . Most candidates applied the properties of isosceles triangles to find angle CBE and angle CEB as 70° . The next step was usually to use angles on a straight line to find angle AED as 50° . Many candidates also found angle ECD as 70° or angle EDC as 50° using alternate angles. Many errors resulted from candidates being unaware of which angles in a parallelogram are equal: it was common to see angle $DAE = \text{angle } CBE$ rather than the correct relationship angle $ADC = \text{angle } CBE$. Some candidates assumed that triangle EDC was equilateral, identified the incorrect pair of equal angles in triangle ECB or assumed that angle ADC was a right angle.

Question 4

Most candidates were able to identify that 28 satisfied the two conditions given in the question. The most common incorrect answer was 35, which satisfied the condition that the number was a multiple of 7 but when rounded to the nearest 10 the result would be 40 rather than 30. Most answers given were in the range 25 to 35, but some candidates gave the answer 4 from the working $4 \times 7 = 28$ which showed a misunderstanding of the term multiple.

Question 5

Many candidates were able to convert the given numbers into equivalent form, usually decimals, and then order them correctly. The most common errors were to place $\frac{17}{20}$ before 84.5% or to place $\frac{7}{9}$ last. Some candidates made errors when dividing to form a decimal, including dividing the denominator by the numerator, and those who attempted to convert all values to percentages often made errors. Candidates should be familiar with simple recurring decimals so that they can write $\frac{7}{9} = 0.777\dots$ without the need to carry out a division.

Question 6

Most candidates solved this equation correctly. The most common errors were incorrect signs when collecting terms, and errors in simple arithmetic such as $9 + 3 = 11$ or $2x = 12$ leading to $x = 4$.

Question 7

- (a) Many candidates were unable to write a correct inequality. Common errors involved incorrect inequality signs such as $x \geq 3$ or $x < 3$ or inequalities that did not involve x , such as $3 < 8$. Some candidates did not understand that the arrow on the line indicated that there was no upper value for the inequality and wrote $3 < x < 8$, which was not acceptable. It should be noted that the syllabus requires candidates to know that an open circle represents a strict inequality and a closed circle represents an inclusive inequality.
- (b) Many candidates solved this inequality correctly. The most common errors were to write 9 on the answer line rather than the inequality $x < 9$ or to reverse the inequality sign when solving leading to $x > 9$.

Question 8

- (a) Most candidates wrote the coordinates correctly, with very few reversing the x - and y -coordinates.
- (b) The most common approach was to set up an equation for the gradient using $(\text{difference in } y) \div (\text{difference in } x)$. Many candidates wrote a correct equation such as $\frac{-1-3}{p-4} = -2$ although it was common to see errors in the rearrangement that led to an incorrect value of p . Common errors in the gradient equation were to use a gradient of 2 rather than -2 or to use $(\text{difference in } x) \div (\text{difference in } y)$. The most successful approach was to use the diagram and draw a line with gradient -2 through point B and identify the point on this line where $y = -1$ as point C , which avoided the need for any algebra. Some wrote the equation $y = -2x + c$ and substituted $(p, -1)$ but did not use the coordinates of point B so were unable to make further progress.
- (c) Candidates found this question challenging and many omitted the question. Those candidates who had shown point C on the diagram and continued to complete the parallelogram on the grid often reached the correct answer. Some candidates understood that, in the parallelogram, sides AB and DC are parallel and used $\overrightarrow{AB} = \begin{pmatrix} 6 \\ 2 \end{pmatrix}$ with the coordinates of C to find the position of D . Some candidates gained partial credit for showing a line CD that correctly followed through from their incorrect position for C .

Question 9

- (a) Many candidates simplified the ratio correctly. Some showed a correct partial simplification such as $30 : 36 : 18$ or $15 : 18 : 9$ but did not fully simplify to $5 : 6 : 3$. A significant number of arithmetic errors were seen when cancelling. The method mark was only available for a partially simplified ratio, so candidates who showed divisions of the three values separately but did not write them together as a ratio did not gain credit. Some candidates started by forming a ratio using fractions $\frac{60}{168} : \frac{72}{168} : \frac{36}{168}$ which they were often unable to simplify further so did not gain credit.
- (b) The most successful approach was to find the number of counters in one part using $\frac{18}{8-5} = 6$ and multiply this by 5 and 8 to reach the correct results. Some candidates considered successive ratios $5 : 8, 10 : 16, 15 : 24$ etc until they reached $30 : 48$ which had the required difference of 18. A minority of candidates used an algebraic approach, setting up an equation such as $\frac{x}{x+18} = \frac{5}{8}$ which they were sometimes able to solve correctly. Common errors were to find $\frac{5}{8} \times 18$ or $\frac{8}{5} \times 18$, to use $5 + 8 = 13$ in their calculations or to simply add 18 to one of 5, 8 or 13.

Question 10

Many candidates correctly converted $1\frac{2}{5}$ to an improper fraction and inverted $\frac{3}{10}$, giving the product $\frac{7}{5} \times \frac{10}{3}$ which they evaluated correctly. The question required a mixed number in its simplest form, and some candidates were unable to convert $\frac{70}{15}$ or $\frac{14}{3}$ to a mixed number. Some left their answer as the unsimplified mixed number $4\frac{10}{15}$ and others did not attempt to form a mixed number. Some candidates had difficulty converting between mixed numbers and improper fractions, with errors such as $1\frac{2}{5} = \frac{7}{2}$ and $\frac{14}{3} = 1\frac{4}{3}$ seen. Few candidates used the common denominator approach of using the division $\frac{14}{10} \div \frac{3}{10}$.

Question 11

- (a) Many candidates identified the transformation as a translation, but candidates had more difficulty identifying the vector for this transformation. Common errors were to use the incorrect terms 'translocation' or 'move' in place of translation. The correct vector was $\begin{pmatrix} -5 \\ -4 \end{pmatrix}$ but one or both negative signs were often omitted, or the components were reversed. Some candidates described the vector in words which was accepted if the directions of movement were stated, for example 5 squares left and 4 squares down.
- (b) Many candidates drew the rotation correctly. Common errors were to rotate by 90° clockwise about an incorrect centre or, less often, to rotate 90° anticlockwise about the origin. It should be noted that to show a transformation of the given shape the image must be drawn on the grid rather than in the space below the question.

Question 12

- (a) (i) This question was very well answered, with many correct sample space diagrams seen and very few arithmetic slips.
- (ii) Many candidates used their table to find the correct probability of obtaining a score greater than 10. Some gave a fraction with either a correct numerator or a correct denominator. Common errors were to use a denominator of 24 in place of 16 or to give an answer of 3 instead of the actual probability.
- (b) This question was found to be more challenging, and some candidates omitted this question. Successful candidates usually drew a second sample space for spinner A using the given sample space as a guide. A common error was to misread the question and to consider using spinner A and spinner B, or spinner B twice rather than spinner A twice. Those candidates who listed outcomes rarely identified the correct six outcomes, usually because they did not consider pairs such as 4×8 and 8×4 as different outcomes or because they did not consider doubles such as 4×4 . Some assumed that spinning A twice produced the four outcomes 4, 8, 12 and 16.

Question 13

This question required candidates to interpret a context and identify the appropriate steps to reach a solution. Many started by finding the amount of the bonus as \$22, although arithmetic errors in $82 - 60$ were common. Some candidates found the amount earned for 5 hours work but made no further progress. Candidates were often unable to correctly interpret the information that the bonus was 5% of the value of the items sold. Many found 5% of 22 or 95% of 22 rather than identifying that 22 was 5% of the total value, leading to the calculation $22 \div 0.05$. Some candidates showed irrelevant calculations such as 12×60 , 5% of 60 or 5% of 82.

Question 14

This question was found to be very challenging, with many candidates demonstrating limited understanding of circle theorems. Candidates often showed angle $ACD = 40^\circ$ on the diagram but did not give a reason to justify this. Many candidates were unable to apply the alternate segment theorem correctly to find angle $ACB = 65^\circ$, with angle ABC often identified incorrectly as 65° . A common error was to treat AC as a diameter and use angle $ABC = 90^\circ$. When asked to give a geometrical reason, candidates are expected to use precise terminology, ideally quoting the reason as it is stated in the syllabus. Many responses were vague or overly descriptive and did not include essential terms such as centre, circumference, or alternate segment. A small number of candidates recognised that $ABCD$ is a cyclic quadrilateral with angle $DAB = 75^\circ$, but reasons given with this approach were usually insufficient.

Question 15

- (a) Most candidates successfully substituted $x = 4$ into the cubic equation to obtain 12. Incorrect answers were generally the result of arithmetic errors, with 2 and -12 being common.
- (b) Many candidates plotted the points accurately and drew a correct smooth curve through the points. Some candidates plotted all points correctly but drew a curve with a maximum point well below their plotted point at $(0, 12)$. It is not acceptable to join the points using ruled line segments when a curve is required.
- (c) This question proved challenging, and many candidates omitted it. Only a minority read the value at which their graph crossed the x -axis. Despite the instruction to 'use your graph', a considerable number of candidates attempted lengthy algebraic solutions. A common incorrect answer was 12, with no working shown.
- (d) This question was very challenging, and many candidates omitted it. The question asked for a line to be drawn on the grid, but many candidates attempted to write solutions with no line drawn. Common incorrect lines drawn were $y = 8$ and $y = 4$. Some candidates attempted to rearrange the given equation to find the required line, but only a minority were able to obtain $y = 8 - x$, draw it accurately on the grid and obtain the three solutions.

Question 16

- (a) Most candidates attempted to expand the two brackets but errors in one of the four terms frequently led to an incorrect result. Common errors included incorrectly simplifying $3 \times 4\sqrt{2}$ to $12\sqrt{6}$, and $\sqrt{2} \times 4\sqrt{2}$ to $\sqrt{4}$, $\sqrt{8}$ or $4\sqrt{2}$. Some candidates attempted to simplify the expressions in the brackets before expanding, for example writing $1 + 4\sqrt{2}$ as $5\sqrt{2}$. Some candidates treated 4 and $\sqrt{2}$ as separate terms and their expansion involved six terms rather than four.
- (b) Many candidates were familiar with the process of rationalising the denominator and some produced the correct answer. Sign errors were often made, such as $1 - 7 = 6$ instead of -6 . Some candidates who had the correct expression in their working introduced errors when attempting to remove the negative sign from the denominator. Some had recognised the process required but multiplied by $\frac{1+\sqrt{7}}{1+\sqrt{7}}$, $\frac{1+\sqrt{7}}{1-\sqrt{7}}$ or $\frac{\sqrt{7}}{\sqrt{7}}$. An answer of $\frac{1}{8}$ was often seen from those who attempted to square $\frac{1}{1+\sqrt{7}}$.

Question 17

- (a) Many candidates seemed unfamiliar with the topic of similarity. Candidates who set up a correct relationship between the sides, for example $\frac{PR}{7} = \frac{9}{6}$, were usually able to reach $PR = 10.5$. Some candidates made errors when simplifying $\frac{63}{6}$. Many candidates did not use the ratio of common sides or the scale factor to find PR and the most common incorrect answer was 10, resulting from use of $9 - 6 = 3$ and $7 + 3 = 10$.

- (b) Many candidates were unaware that they were required to use the scale factor squared to find the area of triangle PQR . Those that set up a correct relationship such as $\frac{A}{16} = \frac{9^2}{6^2}$ often made arithmetic errors because they had not simplified the scale factor to $\frac{3}{2}$ before squaring. Many candidates did not square the scale factor, which led to the common incorrect answer of 24. It was common to see a calculation such as $\frac{1}{2} \times 9 \times 10.5$, which is an incorrect method for the area and did not use the value of 16 given in the question. Some candidates used a long method which involved calculating the height of triangle ABC as $\frac{32}{7}$ then scaling this to find the height of triangle PQR or to find $\sin BAC$ as $\frac{16}{21}$ and using this in $\frac{1}{2}ab \sin C$ to find the area of triangle PQR . These longer methods usually involved errors resulting from premature rounding or forgetting to scale the height for triangle PQR .

Question 18

Candidates found this question very challenging. Many were unable to use the information in the question to identify the required steps of equating the volumes of the two solids, rearranging to find the radius and using the radius to find the surface area of the hemisphere. Some candidates equated the volumes of the cylinder and hemisphere but only a minority rearranged correctly to find the radius of 9. Errors in rearrangement were common, for example incorrect cancellation of π leading to $r = 9\pi$, but some made no attempt to rearrange after reaching $6\pi r^2 = \frac{2}{3}\pi r^3$. Candidates who found a value for the radius often used an incorrect formula for the total surface area of the hemisphere, either $2\pi r^2$ or $4\pi r^2$. Those who did use $3\pi r^2$ sometimes made errors when squaring the radius, or omitted π in their final answer. Many candidates ignored the information about equal volumes and started by attempting to find the surface area of the cylinder, often substituting $r = 6$. In some cases, formulas were quoted incorrectly despite being provided in the list of formulas.

Question 19

- (a) Some candidates demonstrated sound knowledge of the laws of indices, and applied them to reach the correct answer. Many understood that a negative index led to a reciprocal and showed a correct first step of $\frac{1}{16^{\frac{4}{3}}}$ but were not always able to make further progress, particularly if they attempted to cube 16 rather than take the fourth root first. Some simplified as far as 2^{-3} but did not evaluate this as $\frac{1}{8}$. Some were unable to deal with the negative index, and this led to the common errors of $\sqrt[4]{16^3}$ and $16^{\frac{4}{3}}$. Some candidates started by changing 16 to 4^2 , leading to $(4^2)^{\frac{3}{4}}$ but were unable to make further progress. Candidates who were unfamiliar with the laws of indices often attempted fraction calculations with the given values, such as $\frac{16}{1} - \frac{3}{4}$ and $16 \times -\frac{3}{4}$.
- (b) Some candidates converted 9^2 to 3^4 and some then applied the laws of indices correctly to reach the correct answer of $3^{\frac{7}{2}}$. Some candidates wrote $3^4 \times 3^{-\frac{1}{2}}$ but then attempted to cancel the powers, leading to 3^2 or 3^{-2} . The most common approach was to evaluate 9^2 as 81 and then attempt to evaluate $81 \times 3^{-\frac{1}{2}}$ or $81 \div 3$. It was common to see attempts to deal with the powers without first converting to a common base, with attempts such as $9^2 \times 3^{-\frac{1}{2}} = 27^{\frac{3}{2}}$ seen.

Question 20

- (a) Many candidates understand the process for finding the inverse of a function and often gave the correct answer. A common error was to give the final answer as $\frac{y-3}{a}$, in terms of y rather than x .

Some candidates made basic errors in rearrangement with $y+3=ax$, $3-y=ax$ and $\frac{y}{a}=x+3$ being common incorrect first steps. Some candidates did not recognise the notation for an inverse function and treated it as a reciprocal, giving the answer as $\frac{1}{ax+3}$.

- (b) Candidates found this question very demanding, with few fully correct answers seen. Those who understood the composite function notation often started by writing $gf(x) = (ax+3+b)^2$ and equating this with the given expression, however they were often unable to expand this correctly. Some did identify $a=3$, despite having errors in some of the terms in their expansion. Some factorised the given expression to $(3x+4)^2$ but few identified that they could then compare coefficients with $(ax+3+b)^2$ to find both a and b . Common misconceptions included attempts to expand $(ax+3)(x+b)^2$ or substituting either $f(x)$ or $g(x)$ into the given quadratic equation, e.g. $9(ax+3)^2 + 24(ax+3) + 16$.

Question 21

- (a) (i) Candidates were often able to write down the correct answer. Some attempted to add several vectors to reach the answer, in which case the answer was often unsimplified or incorrect.
- (ii) Some candidates were able to apply the ratio $PN:NQ$ correctly, identify a correct vector route and simplify their vector to reach the correct answer. Some gave unsimplified answers such as $\frac{3}{4}2\mathbf{b} - \frac{1}{2}\mathbf{a}$ or $\frac{6}{4}\mathbf{b} - \frac{1}{2}\mathbf{a}$. Candidates whose first step was to write down a vector route for NM usually gained the method mark for an expression such as $NQ + QM$. Candidates should identify the vectors used in their working. The vector $\frac{3}{2}\mathbf{b}$ was often seen but could only be given credit if identified as NQ .
- (b) This question was very challenging, and many candidates did not attempt it. Very few correct responses were seen and those candidates who did attempt it rarely used the similar triangles to identify a correct scale factor of 3 : 1 between triangles NMQ and NXP .

Question 22

- (a) In a 'show that' question, candidates are required to use the information provided to reach the expression given in the question. Many candidates were able to show the result, either writing $\frac{4 \times 60}{x} = \frac{240}{x}$ or by stating 1 hour = 60 minutes, 4 hours = 240 minutes and cards in 4 hours = $\frac{240}{x}$. It was essential for candidates to state the value 60 in their working to justify use of 240 in the expression. Some candidates showed a product but did not complete to the expression $\frac{240}{x}$ and many attempted to work backwards from the given expression to a value of $x=4$ or $x=60$.
- (b) This question was found to be challenging, but those candidates who used the expression given in **part (a)** to help them identify that the number of cards made by Maha was $\frac{240}{x-2}$ were usually able to form a correct equation and attempt to rearrange it to the given equation. Most used a correct common denominator of $x(x-2)$ and often eliminated the fraction and simplified correctly to reach

an equation such as $480x - 480 = 70x^2 - 140x$. Some candidates did not gain full credit because they made an error such as omitting $= 0$ at some stage, omitting necessary brackets or making sign errors when rearranging. Some candidates used $\frac{240}{x} - 2$ in place of $\frac{240}{x-2}$. Many candidates did not understand what was required in this part and attempted to solve the given quadratic equation.

- (c) As this question required the use of factorisation, full credit could not be awarded for solutions that used the quadratic formula. Very few candidates who used the quadratic formula reached the correct solutions as the arithmetic involved was challenging. Those candidates who factorised often reached the correct pair of brackets and gave the correct solutions, but some used incorrect signs such as $(7x - 6)(x + 8)$. Some found the factors but left them in a table or equated each to zero rather than showing them as a product.
- (d) Even candidates who had solved the quadratic equation correctly were often unable to use their solutions to find the correct answer here. Many candidates did not refer back to the expression for the number of cards made by Maha and those that did often gave the answer 40, the number made in 4 hours, rather than 10, the number made in 1 hour. The most common error was to calculate $70 \div 4$, which is the total number of cards made by Ade and Maha in 1 hour.

Question 23

Some candidates realised that they needed to use Pythagoras's theorem to find the required distance, and started with a correct method of $11^2 - 7^2$ leading to $\sqrt{72}$. Some identified that this was half of the distance required so the length of the base was $2\sqrt{72}$. The question required the answer as a surd in its simplest form, so the answer $12\sqrt{2}$ was required for full credit. Some candidates did not attempt to simplify, and others partially simplified to $6\sqrt{8}$ but did not identify that $\sqrt{8}$ could also be simplified to $2\sqrt{2}$. Some candidates incorrectly identified XC as $\sqrt{72}$. Arithmetic errors were not uncommon, such as $11^2 = 111$ or $121 - 49 = 82$. Some candidates attempted to use Pythagoras's theorem but did not use 11 as the hypotenuse. Many candidates did not understand what was required in the question. It was common to see 7 and 11 substituted into the formula for the volume of a pyramid or just to see the dimensions added to the diagram.

MATHEMATICS SYLLABUS D

Paper 4024/21 Calculator

Key messages

To do well on this paper candidates needed to

- be familiar with the whole syllabus including the new content
- understand and use correct mathematical terminology
- select and apply the appropriate mathematical techniques to answer the questions set
- understand how to use a calculator correctly and efficiently to answer questions accurately
- set their work out in clear, logical steps and then transfer their final answer accurately onto the answer line

General comments

There were a number of candidates who achieved high scores on this paper and demonstrated a good understanding and knowledge of the topics covered. However, many more candidates found this paper very challenging.

There were many good responses to questions in the first half of the paper, with many candidates performing well on the straightforward number, algebra and geometry questions, demonstrating good basic arithmetic and algebraic skills. The questions that candidates found most difficult were those assessing probability, trigonometry, 3D geometry and advanced algebra. Some candidates made sign errors when manipulating algebraic expressions and solving equations. Candidates should be reminded of the importance of reviewing their work carefully to minimise avoidable mistakes, such as arithmetic errors, sign errors and transcription errors. There were instances of candidates giving inaccurate final answers due to premature rounding of intermediate values. It is important that candidates retain sufficient significant figures in their working and only round their final answer to 3 significant figures where their answer is not exact.

Comments on specific questions

Question 1

- (a) Most candidates identified 49 as the required square number from the given list of numbers. The most common incorrect answer was $\sqrt{169}$.
- (b) Most candidates identified 27 as the required cube number from the given list of numbers. The most common incorrect answer was $\sqrt{8}$.
- (c) Many candidates identified $\sqrt{169}$ as a factor of 26. However, many gave an answer of 52, confusing factor with multiple.
- (d) Many candidates identified $\sqrt{8}$ as an irrational number. The most common incorrect answer was $\frac{12}{23}$.

Question 2

- (a) Most candidates answered this question correctly. The most common wrong answer seen was $4.2 - (3 \times 5) + 1.2 = 7.2$
- (b) This question was a bit more challenging for some candidates, with common wrong answers of $5 - (3^2 - \sqrt[3]{64}) + 2 = -10$, $5 - 3^2 - (\sqrt[3]{64}) + 2 = -10$, and $(5 - 3^2) - (\sqrt[3]{64}) + 2 = -10$ seen.

Question 3

- (a) Some correct responses were seen to this question, but many candidates found the question challenging, with a lot of weaker candidates calculating the volume rather than the surface area of the cuboid. Other common errors seen were candidates using the wrong dimensions for some of the faces, particularly thinking that one of the faces was a square and calculating 4.7×4.7 or not recognising that the cuboid has got 3 pairs of faces and only calculating the area of 3, 4 or 5 faces.
- (b) Very few candidates were able to correctly give the number of planes of symmetry of a cuboid

Question 4

- (a) Most candidates plotted the 3 points correctly. A small minority of candidates did not plot any points, suggesting that they may not have read the question.
- (b) Many candidates were unable to draw a correct line of best fit within the required tolerance, although some good responses were seen. The most common errors were starting the line of best fit at the origin or joining the first and last points. Some candidates joined all the points or made their line too short.
- (c) Most candidates were able to use their line of best fit to find an estimate for the mathematics mark by reading at 75 marks for physics. The most common error was reading from the horizontal axis rather than the vertical one.

Question 5

- (a) Many candidates were able to calculate the value of x , recognising that x was one of the two equal base angles of the isosceles triangle. The most common error seen was doubling the given angle before taking it away from 180.
- (b) This was answered correctly by most candidates although there were some that used 180 rather than 360 for the sum of angles around a point.

Question 6

There were some good responses seen to this question, with many candidates demonstrating the ability to use their calculator efficiently. The most common error seen came from candidates carrying out the calculation in stages and using a rounded or truncated value for $\sqrt[3]{6}$ of 1.8, 1.81 or 1.82, leading to a final answer of 113.11. Some candidates did not appreciate that the numerator should be evaluated completely or brackets used in their calculation before carrying out the division, leading to an answer of -8.190. Candidates should be encouraged to write down their calculator display to more than 2 decimal places before rounding their answer to the required accuracy.

Question 7

Many candidates knew that a regular decagon had 10 sides and were able to calculate the size of the interior angle using either the fact that the exterior angles add up to 360 or using the formula $\frac{180(n-2)}{n}$. The most common error was forgetting to divide by 10 or thinking the shape had got 12 sides.

Question 8

Most candidates were able to calculate the amount of interest received after 5 years. Some candidates did not read the question carefully and added the value of the initial investment to the correct amount of interest thinking they needed to give the total amount of money in the account. A small number of candidates started

with an incorrect calculation, commonly $\frac{240 \times \frac{2.35}{100} \times 5}{100}$ or $240 \times 2.35 \times 5$ or used the compound interest formula.

Question 9

There were some good responses seen to this question, but many candidates found it challenging. Of those candidates that attempted it, most were able to calculate a correct conversion to one of the given currencies but were then unsure of how to progress to use their answer to get the conversion rate for \$ into £. The most efficient method was to convert €500 into £ and then to use their answer of £440 = \$536.58 to calculate x . The common error seen from this method was candidates getting the division the wrong way round. Some candidates used €500 and \$536.58 to get the conversion rate for € to \$ or \$ to € but then made errors in the next calculation. Some candidates lost accuracy by using prematurely rounded intermediate values.

Question 10

- (a) Most candidates were able to fill in the table for the number of dots in the next two patterns in the sequence. A minority of candidates omitted a value for the fifth pattern. Some candidates omitted this question completely.
- (b) Most candidates were able to give the correct expression for the n th term, with many responses showing the correct use of the formula $a + (n - 1)d$. Several responses worked with the correct common difference of 4 but in some cases this value was used incorrectly, leading to answers of $n + 4$, $n - 4$, or $4 + n - 1$. Some responses involved slips in simplifying $5 + 4(n - 1)$.
- (c) Many candidates were able to calculate the value of p using the n th term expression. A common incorrect answer was to calculate $4 \times 1105 + 1$ rather than equate the n th term expression to 1105

Question 11

- (a) (i) Most candidates were able to calculate $\overline{AB}$. Common errors included calculating $\overline{BA}$, adding the two coordinates to get $\begin{pmatrix} -2 \\ -4 \end{pmatrix}$ or multiplying the coordinates to get $\begin{pmatrix} -8 \\ -21 \end{pmatrix}$.
- (ii) Most candidates were able to calculate the coordinates of the midpoint. The most common approach was to use $(\frac{-4+2}{2}, \frac{3+-7}{2})$ rather than calculate with their vector $\overline{AB}$.
- (b) Many candidates correctly calculated the length of CD although a high number of candidates did not attempt this question. The most common incorrect answer was $\sqrt{96}$ due to candidates omitting brackets when calculating $(-5)^2$.

Question 12

- (a) Most candidates converted to standard form correctly. The most common incorrect answers were 1.42×10^2 , 142×10^{-2} and 1.42×10^{-3} .
- (b) Many candidates found this question challenging but some good responses were seen. The most successful approach used by candidates was to carry out the division on their calculator using (2.6×10^3) and (3.2×10^{-4}) rather than dealing with the elements separately and then converting 8125 000 into standard form. The common incorrect answers of 0.8127 and 7 came from candidates calculating $2.6 \div 3.2$ and then dealing with the powers of 10 separately. Other errors included giving an answer for x to 2 sf and not showing the more accurate exact value, getting the division the wrong way round and subtracting the two numbers rather than dividing.

Question 13

Many candidates were able to make a credible attempt to solve the simultaneous equations, with an equal spread of substitution and elimination methods seen. The most common error was failing to deal with the b terms correctly after equating the a terms, with candidates calculating $6a + 15b - 6a - 20b = 4.5 - 85$ leading to $-5b = -80.5$ rather than $6a + 15b - (6a - 20b) = 4.5 - 85$. Other errors included not multiplying all terms when equating coefficients, arithmetic slips, sign errors when rearranging and omitting negative signs when substituting a solution. Many candidates who had reached an incorrect first solution went on to use this solution correctly to find a pair of values that satisfied one of the equations. Candidates should be encouraged to check their solutions fit both equations as this will help them to identify errors in their working.

Question 14

This question proved challenging for most candidates with many not attempting to answer it. There were some good responses seen from stronger candidates who were able to solve the problem using logarithms and reach an answer of 12 years. A common error seen from candidates using this approach was to round their answer down to 11 or give the answer as 11.1 years rather than appreciating that for the population to reach 8 million they needed to round their answer up as the question required the number of complete years. Some candidates were able to set up the correct compound percentage expression in terms of x and arrived at the answer of 12 years by calculating the population increase in stages, but there were others that were

unable to progress beyond $5.4 \left(1 + \frac{3.6}{100}\right)^n = 8$. Weaker candidates did not appreciate that the population

would grow exponentially and calculated 3.6 per cent of 5.4 and assumed that the population increased by the same amount every year, leading to an answer of 13 years.

Question 15

Stronger candidates were able to find the highest common factor, but the question proved challenging for weaker candidates with many not attempting it. Common errors seen were candidates only getting one of the correct elements or attempting to evaluate their product with 2 of the 3 correct elements.

Question 16

- (a) Many candidates were able to calculate the gradient of the line AB and then went on to get the equation of the line AB by calculating the y intercept using one of the given coordinates. Some of the common errors seen were in the rearrangement of the equation when finding the value of c , sign errors and getting the numerator and denominator the wrong way round when calculating the gradient.
- (b) Most candidates found this part more challenging, with many not attempting it, although there were some candidates who were able to use their gradient of line AB from **part (a)** to find the correct perpendicular gradient. Common errors in finding the gradient of a line perpendicular to AB were to use the reciprocal of the gradient of line AB or to use the negative gradient, rather than the negative reciprocal.

Question 17

- (a) Many candidates were successful in estimating the mean time. A few candidates made one or more slips, often when finding the midpoint values of the intervals. Incorrect methods seen often involved the use of the class widths instead of midpoint values, using the upper bounds of the intervals instead of the midpoints, and dividing the total score by the number of intervals instead of the total frequency. Candidates should be encouraged to not give their final answer to 2 significant figures or as an interval unless they have shown a more accurate or exact answer in their working.
- (b) Many candidates had difficulty answering this question fully. Most of them were able to identify the probability of the first person selected taking 30 minutes or less but did not recognise that the pool of people was then reduced by one, so it was common to see the probability for the second person having a denominator of 80 rather than 79. Other common errors seen were candidates adding the two fractions rather than calculating the product and candidate not multiplying their product by 2.

Question 18

- (a) There were many good responses seen to this question with most candidates able to rewrite the calculation as $\left(\frac{2x}{3y} \times \frac{9}{8x}\right)$ before attempting to simplify the 3 elements with some candidates being more successful than others. The most common error seen was leaving x in the numerator and/or the denominator.
- (b) Many candidates found this question challenging. Some candidates were able to factorise both the numerator and denominator correctly and cancel to give the required result. Factorisation of the denominator to $(2x - 5)(2x + 5)$ was often correct although there were a lot of candidates that did not recognise the expression as being the difference of two squares, with the common wrong expression of $(2x - 5)^2$ seen. Candidates had more difficulty in factorising the numerator. One of the most common errors seen was $2x^2 - 10x + 5x - 50$ leading to $2x(x - 5) - 5(x + 10)$. Many candidates did not recognise the need to factorise both parts of the algebraic fraction in order to simplify it and made errors when attempting to simplify due to cancelling of individual terms rather than common factors.

Question 19

Most candidates found this question challenging. Stronger candidates showed an understanding of the need to find bounds for both the distance and the time as a first step and recognised the need to use the lower bound for the distance and the upper bound for the time to calculate the lower bound for the average speed. Some candidates were uncertain which bounds to work with and one of the most common mistakes was to use both lower bounds. Some candidates made errors in calculating the upper and lower bounds, with the most common one being 320 ± 0.5 and 5.2 ± 0.5 . Many candidates divided the given values first and then tried to find the lower bound of the resulting speed.

Question 20

- (a) Many candidates identified that the cosine rule was required to calculate BC , substituted the relevant values into the formula and evaluated it correctly to calculate BC . Candidates should be encouraged to give their answers to more decimal places than the required accuracy in order to show that their answer will round to 124.3
- (b) There were some good responses to this question, but many candidates found it challenging and a lot of candidates omitted this question. Some candidates recognised that the sine rule was required but made errors when substituting values or when rearranging to isolate $\sin B$. Premature approximation to less than 3 sf of intermediate values led to inaccurate final answers for some candidates.
- (c) Many candidates found this question challenging although there were some correct responses seen. Of the candidates who answered this question correctly, most used trigonometry rather than equating the two expressions for the area of the triangle to calculate the perpendicular distance from A to BC . The common errors seen were candidates using the wrong trigonometric function, assuming that the perpendicular distance bisected angle A and/or bisected BC and attempting to use Pythagoras' theorem. It is important that candidates demonstrate that they know the shortest distance is the perpendicular line from A to BC by indicating it with the right angle on the diagram even if they are unsure of how to then calculate the distance.

Question 21

Many candidates found this question challenging although there were some good responses seen. Of the candidates that attempted this question, many were able to clear the fraction by multiplying through by $(3a - 1)$ and then correctly expanded the bracket but then had difficulty in knowing what to do next. Common errors seen were candidates dividing by w before expanding the bracket, not isolating the terms in a and sign errors when rearranging.

Question 22

- (a) Most candidates recognised the graph to be a linear function and drew a straight-line graph with a negative gradient and a positive y intercept. Common errors seen were drawing a graph with a positive gradient or drawing a curve.

- (b)(i) Most candidates found this question extremely challenging with only a small number successfully gaining full or partial credit. Very few candidates expanded $a(x - b)^2 + c$ and compared the coefficients of the two expressions instead opting to attempt to complete the square by halving the coefficient of the x term. The most common error was candidates not considering the coefficient of the x^2 term and taking out a factor of 2 as the first step to get $2(x^2 - 2x)$, resulting in the common wrong answer of $2(x - 2)^2 - 3$.
- (ii) This question was quite challenging for most candidates with many weaker candidates not attempting it. Some candidates were unfamiliar with the basic quadratic shape and various graphs including cubics, reciprocals, V-shapes and straight lines were seen. Stronger candidates made the connection between the coordinates of the turning point and their completed square answer to be able to draw a fully correct graph with the pertinent points labelled, and some candidates worked out coordinates for the graph by substituting values for x and so were able to draw a correct sketch. Common errors seen were candidates not labelling the y intercept and turning point accurately, with values on the relevant axes, or drawing a negative parabola.

Question 23

Many candidates solved this equation, with most of them able to write the left-hand side correctly over a common denominator. The denominator was then eliminated correctly and the brackets expanded to reach the correct equation $x^2 - 5x - 4x - 12 = x^2 - 5x + 3x - 15$. Most candidates who reached this equation went on to rearrange it correctly and give the correct solution. Some candidates made sign errors when expanding the brackets, most commonly getting +12 rather than -12, or when collecting terms. Weaker candidates attempted incorrect cancellation of individual terms in the numerator and denominator before eliminating the denominator or were unable to remove the denominator.

Question 24

There were some good responses seen to this question, with candidates correctly expanding the three brackets and then simplifying their answer correctly, but many candidates had difficulty in producing a fully correct solution. The majority expanded two of the brackets correctly but did not multiply all of the elements by the elements in the third bracket, usually due to the omission of necessary brackets. A few carried out all the multiplications correctly but then made slips in collecting like terms.

Question 25

- (a) Some candidates found this question challenging, with many weaker ones not attempting it or not recognising the need to use Pythagoras' theorem. Of the candidates that were successful in answering this question, very few used the more efficient calculation of $\sqrt{12^2 + 10^2 + 7^2}$ with most of them opting to work in stages, calculating EG first and then using their answer to calculate CE . This method often led to an inaccurate value for CE due to candidates using a rounded value of 15.6 for EG rather than using $\sqrt{244}$. Some candidates worked out EG but were unsure of how to progress further. Candidates should be encouraged to give their answers to more decimal places than the required accuracy in order to show that their answer will round to 17.1
- (b) This question was challenging for many candidates with most of them not recognising that they were required to calculate angle CEG , although there were some good responses seen. Most candidates that identified the correct angle were successful in calculating it correctly.

MATHEMATICS SYLLABUS D

Paper 4024/22
Calculator

Key messages

To do well in this paper, candidates need to be familiar with all aspects of the syllabus. The application of formulas is required as well as the ability to interpret situations mathematically and problem solve with unstructured questions.

Work should be clearly and concisely expressed and intermediate values within longer methods should not be rounded, with only the final answer rounded to the appropriate degree of accuracy.

Candidates should show full working with their answers to ensure that method marks are considered when the final answer is incorrect.

General comments

This was the first November session of assessment for the new syllabus and overall candidates found this paper challenging although all appeared to have enough time to complete the questions.

Most candidates made good use of the formula sheet provided, for example in **Question 22(b)** usually starting with a correct version of the cosine rule. However, while many candidates were able to quote the sine rule, it was apparent that some candidates did not understand the notation that pairs the sides and angles correctly.

Most candidates presented their work well and therefore had the opportunity to gain partial credit when solutions were not entirely correct.

The most challenging topics included exponential decrease and increase in population, curve sketching, LCM, HCF and cube numbers in prime factor form, all with some algebraic content requiring interpretation, interpreting a Venn diagram to calculate probability, identifying the shortest distance from a point to a line and accurate time conversions. All but the strongest candidates also struggled with coordinate geometry.

The topics that were most accessible included working with simple measures, constructing a triangle, simple algebraic manipulation, expectation from relative frequency, standard form and the use of a calculator.

Comments on specific questions

Question 1

Many candidates gave the correctly rounded answer. The common errors were truncating to 16.17 or not rounding the answer to 2 decimal places.

Question 2

- (a) Although correct answers were seen, this question proved challenging for many candidates. The most common error was not ordering the data prior to finding the average of the middle two values in the given list. Other candidates confused median and mean, though some of them ordered the data correctly to gain partial credit.

- (b) More correct answers were seen to this part, which proved more accessible than the previous part. The most common errors were not finding a value for the range and giving the answer as $10 - 35$ or not ordering the given values and working out $22 - 16 = 6$ using the first and last values.

Question 3

This was very well answered well. A few candidates converted 5 kg incorrectly to 500 g and then subtracted from 900 g giving the answer 400 g. A few others did not realise a difference was required and used division.

Question 4

- (a) The construction was answered completed. Some candidates did not use compasses to construct the triangle but gave a reasonably accurate position for vertex *C* to earn partial credit. Candidates should always leave construction arcs visible and not try to erase them afterwards. Just a few were inaccurate with the required lengths for *AC* or *BC*.
- (b) This part was less well answered. Some of the answers indicated that candidates were reading the wrong scale on their protractors, resulting in an answer greater than 90° . Others may not have used a protractor at all.

Question 5

- (a) Many candidates calculated the simple interest correctly. However, a significant number of candidates then used this interest in a second step to either add or subtract the interest to \$400, with most adding to give an answer of \$433.60. A few showed $400 \times 2.8 \text{ per cent} \times 3$ as their method without interpreting 2.8 per cent as $2.8 \div 100$. In cases where the interest was evaluated incorrectly, credit could not be awarded unless 2.8 per cent was interpreted correctly within the method.
- (b) Few candidates gave the correct answer. The most common error was to misunderstand the demand and give the answer of 4.80, which is the total for 3 years. Some attempted longer complex calculations and did not use the mark allocation as a guide for the work required.

Question 6

Most candidates started this question correctly by multiplying 5000 and 8.3 but the conversion of units then caused issues. The most common incorrect answer was 41500, but there were other answers with the figures 415 in them. A few candidates were unable to use the scale correctly and divided 5000 by 8.3 to begin with.

Question 7

This question was generally answered very well. Some candidates did not fully factorise the expression so only gained partial credit.

Question 8

Most candidates showed the correct expansion of the brackets and then went on to collect like terms correctly. The most common error in expansion was with the second bracket: $5(x + 1) = 5x + 1$.

Question 9

Candidates who worked with exterior angles were generally more successful than those who worked with interior angles. Many showed a correct method to find either an interior or an exterior angle of one or both polygons, but a significant number then assigned these values to the incorrect angles and confused interior and exterior angles. A few candidates combined the pentagon and hexagon into one 'polygon' and then tried to find the exterior angle of a 9-sided or 11-sided polygon.

Question 10

- (a) Many candidates gave the correct answer. Of the candidates who did not gain full credit, many obtained partial credit by correctly multiplying the vector $\begin{pmatrix} -3 \\ 4 \end{pmatrix}$ by 3 in working. Most errors were made when subtracting the vector **b**, including $12 - (-2) = 10$ rather than 14 and $-9 - 8 = -1$ rather than -17 .
- (b) This question proved challenging for candidates, with a minority getting the answer correct. Many started well, adding the vectors correctly and then attempting to work with 5 and 2. Most, however, did not understand the magnitude notation and made no attempt at finding the magnitude of the vector **a** + **b**. Some attempted to work with Pythagoras, but often with incorrect values, or found the magnitude of **a** – **b**. A small but significant number found the magnitude of both vector **a** and then vector **b** and then added the two values. Candidates should note that answers to magnitude questions like this can be left as surds but if evaluated as decimals then answers should be given correct to at least 3 significant figures.

Question 11

Almost all candidates gave a correct answer. A few gained partial credit only as they did the calculation in stages but after $125\,000 \div 2000 = 62.5$ they prematurely rounded this to 63, leading to an inaccurate final answer. A few others worked with an incorrect number of zeros in the value 125 000.

Question 12

- (a) Most candidates answered this well. The most common errors were to give answers of 372×10^6 or 3.72×1^{-8} .
- (b) Most candidates also answered this part well. Others gained partial credit for giving a correct answer to the calculation (0.034) but being unable to convert to standard form. Some others did not show an answer to the calculation and went straight to an incorrect standard form answer. Partial credit could not be awarded here as the correct value of 0.034 was not seen in working.

Question 13

- (a) (i) Almost all candidates gave the correct next term.
- (ii) This part was well answered, with most candidates gaining full credit. Some gave a simplified answer $5n + 2$, others gave $3 + (n - 1)5$. Both were accepted. The most common incorrect answer was $n + 5$.
- (b) This part was more challenging but correct solutions were seen. Some candidates attempted to write each of the terms up to T_{25} . This approach was rarely successful and often included arithmetic slips with so many terms to write. Candidates who used a generalised approach were generally more successful. Many gave a correct numerator for partial credit. Those that recognised that the denominators were square numbers were often successful, but a significant number gave either 576 or 625 as the answer from 24^2 or 25^2 . Some did not spot that the denominators were square numbers and attempted to find the pattern using differences, which was unsuccessful. A reasonable high number of candidates omitted this part.

Question 14

- (a) Most candidates recognised that they needed to represent the numbers as multiples of prime factors, and many gained some credit for doing this successfully, at least for 360. Most did not understand what to do beyond that. A very common idea was to compare the prime factors of 16200 with those of 360, and find the difference between their indices, so that $x = 2$ and $y = 1$ was a common incorrect answer. Few candidates realised that it was the highest index in each of the numbers 360 and N that was significant for the LCM.
- (b) This part proved challenging, with few candidates reaching the correct solution and a high number of candidates omitting the question. There were no patterns to the incorrect answers, with many appearing to be random guesses.

- (c) This part proved very challenging with very few candidates giving a correct answer and a very high number of candidates omitting the question.

Question 15

- (a) This part was well answered, with many candidates writing both bounds correctly. There was a wide variety of incorrect answers, the most common being 2.4, 2.6 and 2, 3. Candidates should note that the upper bound for this continuous data is 2.55. Some gave 2.54, having correctly given 2.45 as the lower bound.
- (b) This part was less well answered. A number found combining the two aspects of the calculation challenging and did not understand which number to multiply by 12 and how the bounds should be applied. A very common incorrect answer was 96.6, from 8.05 multiplied by 12. Others multiplied 2.5, rather than their upper bound, by 12 and then added 8.05.

Question 16

- (a) There were only a few correct answers to this part, with most candidates considering a linear rather than exponential decrease. Some simply found the per cent difference between 2020 and 2023, to get an answer of 14.26 per cent. Others divided this value by 3, to get a yearly rate of 4.75 per cent. Some had the correct idea of a cubic expression, but put it equal to the difference between the two values rather than the ratio. Those that started with a correct initial statement such as
- $$120\,000 \times \left(1 - \frac{x}{100}\right)^3 = 102\,885$$
- usually went on to give a correct answer.
- (b) Again, in the part, most candidates did not appreciate the exponential aspect, with many opting to work with a linear increase of 1.6 per cent per year, so that 2034 (10.4 or 11 years) was a common incorrect answer. Around 15 per cent were successful here, with most setting up a statement e.g.
- $$102\,885 \times \left(1 + \frac{1.6}{100}\right)^n$$
- and then using trials to find the first value of n that gave a population greater than 120 000. A few had been taught logs which is not required on the syllabus but was given credit as a correct alternate method.

Question 17

- (a) Sketching graphs is a new area of the syllabus for this year, and it proved challenging for candidates. To be successful here candidates need to know the basic shape for a positive cubic and indicate the position of the y -intercept. Many were uncertain of the shape they were aiming for and both linear and quadratic graphs were common. Some tried to plot the cubic graph using a table of values which is not a suitable strategy for a sketch. Some gained partial credit for drawing a positive cubic graph with no indication of the y -intercept.
- (b) Again, candidates found this part very challenging. A common error was to sketch a reciprocal graph, although a wide variety of other graphs was seen, including quadratic and linear. Some candidates gained credit for indicating that their sketch went through (0, 1) even when the shape of the graph was incorrect.

Question 18

- (a) This question proved challenging for many candidates, but some candidates stated the correct gradient of line L . The most common incorrect answer was $\frac{x}{5}$, while other responses gave values that did not appear to be obvious from the equation.
- (b)(i) Many candidates who had the correct gradient in **part (a)** knew that a parallel line would have an same gradient. Some attempts were made to correctly substitute the coordinates of point A to find the equation of line M . Some candidates did not complete the question by obtaining B in coordinate form and instead stopped at $x = 0$ and $y = -3$. As this was a 'show that' question, candidates needed to establish that point B has coordinates (0, -3) rather than using this fact within the

method. Some candidates gave a circular argument by using the points A and B to find the gradient of a line joining those points and then went on to show that B must have coordinates $(0, -3)$.

- (ii) Few candidates correctly found the coordinates of point C . Some were able to find the correct equation for the perpendicular bisector but did not know how to find the point where it crossed the x -axis. Others gained partial credit for finding the coordinates of the midpoint of line AB or for giving the correct gradient of line N . Some found the correct gradient but then incorrectly attempted to use the coordinates of A to find the equation of the perpendicular bisector. Almost half of all candidates made no attempt at this part.

Question 19

- (a) Almost all candidates gave the correct answer.
- (b) This was much more challenging. The most common incorrect answer was 13 (from $7 + 6$). Some candidates were confused about the notation and gave their answer as a set of numbers, for example $\{7, 5\}$, rather than as a single number.
- (c) A minority of candidates gave a correct answer in this part. Many candidates gained partial credit by identifying that the probability a student studied History was $\frac{9}{22}$. This was often given as the answer or in some cases candidates used $\frac{9}{22}$ each time within their product. Many candidates did not attempt a product of three probabilities, and a common incorrect answer was $\frac{3}{22}$.

Question 20

Many candidates were able to express the inverse proportionality between y and $(x - 3)^2$ as a correct equation such as $y = \frac{k}{(x - 3)^2}$. Of these candidates, most went on to find the correct value of y when $x = -2$.

However, some candidates made numerical errors in evaluating k from $4 = \frac{k}{(7 - 3)^2}$ or evaluated $(-2 - 3)^2$ as -25 . Other candidates used the correct relationship to find k but then reverted to $y = \frac{k}{x}$ to find y when $x = -2$. Some candidates began with the incorrect statement $y = k(x - 3)^2$ or $y = \frac{k}{x}$.

Question 21

To gain full credit, candidates needed to be able to manipulate an equation with algebraic fractions to create a quadratic equation. They then needed to show clear substitution of the values for a , b , and c into the quadratic formula, which is provided on the formula sheet, or they could choose to solve the equation by

completing the square. Candidates whose first step was to write $\frac{2x+1}{x+4} = x - 5$ leading to

$2x + 1 = (x + 4)(x - 5)$ were most likely to reach the correct equation $x^2 - 3x - 21 = 0$. However, some candidates using this approach made sign errors when expanding the brackets or when rearranging to equal 0 or omitted essential brackets, writing $2x + 1 = x + 4(x - 5)$ so that a quadratic equation was never achieved. Candidates who instead multiplied by $x + 4$ as their first step often omitted to multiply the $+ 5$ term, leading to $2x + 1 + 5 = x(x + 4)$. Other candidates correctly reached $\frac{2x+1+5(x+4)}{x+4}$ for the left hand side but did not

equate it to x , often equating to 0 instead. Candidates who reached a quadratic equation were usually able to gain credit for showing their substitution into the quadratic formula. However, writing $(-3)^2$ as -3^2 was common. In general, more care needs to be taken in when the coefficients a , b or c are negative. When the question instructs candidates to show all their working, candidates will not gain full credit for just writing down

a solution that can be generated by their calculator such as $= \frac{3 \pm \sqrt{93}}{2}$. Some candidates did not gain the final accuracy mark as they gave their answer to only 1 decimal place.

Question 22

- (a) Many candidates correctly identified the most efficient approach and correctly used trigonometry to find side AB . However, a significant number of candidates applied the trigonometry ratio incorrectly and used $\sin 42$ instead of $\cos 42$, and other candidates attempted to use the sine rule but paired side AB with angle 42 instead of angle 48 .
- (b) There was a mixed response to this question part. Candidates who identified the need to use the cosine rule usually substituted correctly into the form of the formula provided on the formula sheet. Of these, many rearranged correctly and continued to a fully correct solution, showing the more accurate value $61.48\dots$ to gain full credit. Others did not gain the final accuracy mark as they only stated the value 61.5 and not a more accurate version. Some candidates incorrectly rearranged the cosine formula to the angle form. Candidates who recalled the angle form of the cosine rule generally fared better overall than those who used the side version of the rule. Many other candidates attempted to use the sine rule, sometimes including the angle 61.5 in their work which did not gain credit.
- (c) This question required candidates to identify and calculate CX , the shortest distance from C to BD before calculating a speed involving a unit conversion from m/s to km/h . To gain full credit, candidates needed to maintain a sufficient degree of accuracy throughout. Some candidates who showed an excellent understanding of the methods involved lost accuracy due to premature rounding when converting 6 minutes and 24 seconds to hours. Fully correct solutions were in the minority and a reasonably high number of candidate omitted this part. Some candidates drew the line CX on their diagram but did not identify the right angle at X using the box notation. A common error even after identifying the right angle was to assume incorrectly that X was the mid-point of BD and so the value 247.5 was used in a trigonometry or Pythagoras calculation to find CX . Most candidates understood that the speed should be calculated from a distance divided by a time. However, it was common for candidates to make no attempt, an incorrect attempt or only a partial attempt to convert 6 minutes 24 seconds into hours. Some candidates never converted the distance CX from metres to km in the calculation.

Question 23

This question proved to be challenging, and fully correct solutions were in the minority. Many candidates gained partial credit for finding the area of the sector OAB , but the error $\frac{130}{360} \times 2\pi r$ was also seen. Most

candidates attempted to find the area of triangles OAC and OBC to then add to the area of sector OAB . Some candidates correctly identified angle AOC or angle BOC as 115 and some were then able to successfully find the areas. A very common error was to incorrectly identify angle ACB as 65° and hence

angle ACO as 32.5° . Other candidates assumed triangle AOC had a right-angle at O and used $\frac{1}{2} \times 7 \times 10$

for the area. The final step in this multistep problem was to express the area of the shaded shape as a percentage of the area of the large circle and some candidates were able to show an appropriate calculation mark using their calculated shaded area.

Question 24

- (a) There was a very mixed response to this question part. Many candidates wrote down the correct relationship $0.7 = \frac{f}{40}$ and then continued by writing $f = 0.7 \times 40 = 28$ to gain credit. Some candidates did not show the product, which was required for this 'show that' question. Many other candidates omitted this question part or were unable to correctly recall that frequency = frequency density $\times$ group width.
- (b) The response to this question part was very mixed, with candidates achieving the full range of marks from. Many candidates gained partial credit either for using the mid-interval values or for calculating the frequencies for each interval. Common errors included using interval widths or

upper boundaries for the mid-interval values and using frequency densities instead of frequencies. It was common for candidates to divide the sum of the frequencies by 250. Most candidates showed clear working to accompany their calculations and so were able to gain partial credit.