MATHEMATICS

Paper 0980/11
Paper 11 (Core)

Key messages

To succeed with this paper, candidates need to have completed the full Core syllabus. Candidates are reminded of the need to read the questions carefully, focussing on instructions and key words. Candidates also need to check that their answers are in the correct form, make sense in context and are accurate.

General comments

This paper proved accessible to many candidates. There were a number of questions that were standard processes and these questions proved to be well understood. Most candidates showed some working with the more able candidates setting their work out clearly and neatly. There were other questions that were more demanding, for example finding the local time for a plane's arrival and the area of a sector of a circle.

When calculations of two or more steps are needed it is best if all steps are shown separately for ease of checking by the candidate and for method marks to be awarded if the answer is incorrect. This is particularly important with algebra questions such as **Question 14** along with **Questions 8**, **10**, **11** and **15**.

The questions that presented least difficulty were **Questions 1**, **6(a)**, **7(b)**, **8** and **9(a)**. Those that proved to be the most challenging were **Questions 11**, mean calculation from a bar chart, **13**, radius of a disc, **15**, an approximation and explanation, **20(b)**, set notation, and **21**, area of a sector of a circle. There were few questions left blank but those that were the most likely to be blank were **Questions 17**, **19**, **20(b)** and **21**. The last two have already been mentioned as questions candidates found challenging.

Comments on specific questions

Question 1

This was answered well by most candidates. Occasionally, candidates were incorrect with the fraction which caused problems with the percentage when they tried to follow through with their incorrect value. Sometimes the percentage was given as 2.5 or 250.

Question 2

This proved challenging to some as it relied on the understanding of the word perimeter, as frequently the number of squares (area) was given instead of the distance around the shape. Those that did understand the need to find the perimeter occasionally made arithmetic errors in the addition or missed out one or other of the 1 cm sides. Crossing off the sides when the lengths have been added is a good strategy to use.

Question 3

This was answered well by many candidates. A significant number drew lines of symmetry or stated angles rather than the order of rotational symmetry.

Question 4

This was a well answered question. There was only one correct answer so those that gave the correct and an incorrect answer gained no credit. Incorrect answers were most often *B* (the same orientation) or *C* (an enlargement). Occasionally the answer *F* was given as if the candidates were labelling the shaded shape.

Question 5

Some candidates were very confident with both parts but the concept of the stem was not known or understood by many.

(a) A very common answer was 2 either because candidates forgot they needed to include the 2 from the stem (making 22) or because 2 was the most common digit in the entire diagram.

(b) Again, the stem was often ignored and the candidates ordered the single digits from within the table and so gave 4 as their answer. Some understood the concept of stem-and-leaf diagrams but still listed every number out, often arriving at the correct answer but doing far more work than was necessary and introducing places where errors could be made. Some candidates gave the mean.

Question 6

Both parts were answered well.

(a) Some candidates did not know the conversion factor for changing kilometres to metres, leading to common incorrect answers of 270 (as if they were converting centimetres to metres) or 0.027 (dividing by 1000 instead of multiplying).

(b) This part was almost always correct.

Question 7

(a) A minority of candidates answered this problem solving question correctly and demonstrated a clear ability to deal with flight times combined with time zones and the 24-hour clock. Other candidates correctly found 11 15 (time in Los Angeles when the plane arrived) but did not find the local time in Shanghai or found 12 40 (time in Shanghai when the plane took off) but did not include the time of the flight. Some subtracted the 15 hours or went back in time by taking off the length of the flight from the leaving time. Other errors seen included adding 13 h 35 mins to 21 40 as 34 75 but being unable to convert this firstly to 35 15 and then to 11 15; being unclear to the differences between, for example, 21 40 and 09 40; incorrect use of am and pm and slips with arithmetic. Some had difficulties moving from one day to the next, as a common error was to miscount the time 00 00 either by adding two hours instead of one or accidentally skipping it. Many candidates forgot to write the day, although they got the date and time correct, or wrote the incorrect day with the correct date. Some also used the decimal number system whilst adding the times and forgot that there are 60 minutes in an hour. Lack of working or confused working cost many candidates' credit.

(b) Errors seen in this part were of two types; dividing the price in dollars by the exchange rate instead of multiplying or giving an answer rounded to the nearest dollar instead of including the cents.

Question 8

Many candidates answered this question correctly. Many gained the mark for a correct substitution although some wrote 38 instead of 3×8. After this stage, the most common error was to make one or more sign errors when rearranging.

Question 9

(a) Many candidates measured in centimetres accurately then multiplied by 4 to get the distance in kilometres. A few were not very accurate with their measuring, but if they then multiplied their less accurate measurement by 4, the method mark was gained.

(b) This part was not answered particularly well. Common errors came from not positioning the protractor in the correct place. Common incorrect answers were 025 (from 90 – 65) and 245 (from 180 + 65), the reverse bearing.

(c) There were many accurate responses seen. A few positioned X on a bearing of 140 from Q. Candidates needed to take care with the measurement of length of the line for P to X as inaccuracies like those in **part (a)** were seen here.

Question 10

Most candidates were able to calculate the interest, although many did not add this to the principal to find the total value. Candidates must read the question carefully as some questions ask for the interest only but not in this question. Some gave a rounded answer and another error was to treat this as a compound interest question.

Question 11

Only a few candidates were successful, gaining full credit. Most attempted to read the frequencies from the bar chart, although many made errors, with frequencies such as 14.5 being seen. Candidates must remember the context of a question; all the heights of the bars had to be whole numbers as this was the number of people who gave each score. Very few calculated $\sum fx$ and most just added the frequencies, often incorrectly even though the total frequency was given in the question, and then divided by 6. Quite a few candidates stated incorrectly that $4 \times 0 = 4$. A few showed the method but then gave their answer as 3 instead 3.08.

Question 12

(a) This question was found to be very accessible by most candidates.

(b) The most common errors were to give the next term, 14, or to write $n - 4$.

(c) Only very few of the candidates gained full credit in this part, with many showing the difference of 2 in their working but being unsure how to proceed. Many had learnt the expression, $a + (n - 1)d$ but did not know how to substitute in the difference or the first term. The negative also caused further problems with the algebra.

Question 13

This question was not answered well. Incorrect values of π were used frequently and values were rounded in the middle of the calculation (for those that found the diameter, wrote down a rounded value then halved for the radius). There was some confusion about which formula to use as many used the area formula, dividing by π then square rooting. Some divided by π but then did not divide this by 2 or sometimes, divided by 2 twice.

Question 14

(a) This part was answered well with many candidates gaining full credit or partial credit for a correct partial factorisation. Some factored out the $6x$ but then in their answer only gave the remaining factor, $(3x - 2)$. Some treated this as an equation and went on to try to solve it.

(b) Fewer candidates gained full credit in this part. A number of candidates wrote that $+ 5x - 3x$ was $-2x$ or $\pm 8x$ following on from a correct expansion suggesting they had misunderstood the rules about positive and negative signs but had handled the more complex process correctly.

Question 15

(a) There were few correct answers seen in this part. Most candidates did not round both given numbers to 1 significant figure with the cost per book often being given as \$22 rather than \$20. Many worked out the answer to a calculation involving exact or rounded values and then rounded or truncated their answer to 1 significant figure. A few wrote 1400 on the answer line but did not show their rounded values or their calculation. Showing the values and calculation was vital to be able to answer the next part.

(b) Most candidates incorrectly stated that the estimate would be greater than the actual cost. Those who said it would be less often described the process for rounding numbers rather than how this had affected the result in this case. A large number referred to only one value rather than both.

Question 16

45° was a very common incorrect answer and some candidates found the total of the interior angles of the octagon, 1080°, but then did not go on and divide this by 8. Other candidates started with an incorrect polygon formulae and others did not remember that an octagon had 8 sides.

Question 17

Some candidates were successful in showing the necessary logical working, first, 1 – 0.1 = 0.9 then subdividing that to get to find one part twice the size of the other, i.e. 0.6 and 0.3 in this order. Others tried various methods and some did not write their answers in the table, as instructed, so only gained partial credit if it was not clear which relative frequency was which.

Question 18

Many candidates showed clear working and gave all of the relevant steps required to evaluate the calculation. Most candidates, who were able to convert the mixed number to an improper fraction, went on to add the two fractions correctly. Some candidates who got as far as $\frac{67}{30}$ stopped without giving the answer as a mixed number as asked for in the question.

Question 19

There were few correct answers seen in this question. Most candidates did not interpret the scales correctly and counted squares when finding the gradient, leading to a common incorrect value of $m = 1.5$. Some read coordinates from the graph but were unable to use these to evaluate the gradient correctly from using 'rise/run'. There were a few triangles drawn on the graph often without lengths of sides. The most common mark was for writing $y = mx + 2$, with a variety of incorrect values seen for m.

Question 20

(a) Most candidates gained credit, usually for placing the values 10 and 6 in the correct places on the Venn diagram. The majority made an error when working with the value 23, with most writing this into the diagram directly, rather than realising they needed to subtract 10, before writing 13 and 10 on the Venn diagram. Some wrote 23, 10 and 6 on the diagram, leaving the remaining section blank. Occasionally, two values were written in one section.

(b) There were many errors seen in this part. A large number found $n(C \cap B)$ or $n(C)$. Many candidates made arithmetic errors, despite having access to a calculator. Those who had left a section blank in **part (a)** often only added their two values. It was possible to gain the mark even if the previous part was incorrect; the 50 families minus the 6 families without a car and without a bicycle is 44 families.

Question 21

Some candidates rounded their answer to 2 significant figures or used an inaccurate value of 3.14 or $\frac{22}{7}$ for π. A number of candidates recognised the need to find the area of the whole circle, but many made no further progress. Many others had no idea how to approach this, with attempts that involved multiplying and dividing the numbers in the question or use of trigonometry.

MATHEMATICS

Paper 0980/21
Paper 21 (Extended)

Key messages

To succeed in this paper candidates need to have completed full syllabus coverage, remember necessary formulae and definitions and show all working clearly. They should be encouraged to spend some time looking for the most efficient methods suitable in varying situations. This was particularly important in **Questions 1**, **8**, **10** and **21**.

General comments

The level and variety of the paper was such that candidates were able to fully demonstrate their knowledge and ability. Working was generally well set out. Candidates should ensure that their numbers are distinguishable, particularly between 1 and 7 and between 4 and 9 and should always cross through errors and replace rather than try and write over answers.

Candidates need to be reminded that prematurely rounded intermediate answers bring about a lack of accuracy when the final answer is reached. Checking that answers are sensible should also be encouraged. Algebraic manipulation involving brackets was an issue in **Questions 13**, **17** and **19**; an area for centres to address. Many candidates get into the habit of leading one line of working into the next, particularly in algebra questions. For example, in **Question 17**, within a first line of working of $y - yx = 3x - 2$, candidates then often carried out the next step incorrectly, for example by crossing out the x from both sides, rather than writing out the next line as the next step. Clear, methodical working showing all steps clearly and separately should be encouraged.

Candidates should always check that their calculator is in the correct degrees mode for angles. It should also be emphasised that the general instruction of rounding an answer to 3 significant figures only applies to inexact answers; where an answer is exact, it should not be rounded.

Comments on specific questions

Question 1

There were few candidates who did not score any marks on this first question. Many did get the correct answer but there were almost as many who were not able to deal with the fact that there were two conditions to be satisfied. Many stated either a prime number in the range, often 61, or found the only square number in the range and subtracted 2 to give the very common answer of 62.

Question 2

There was a large range of understanding in **part (a)**, for both the concept and dealing with time. The most successful candidates took each stage separately and converted the interim step to an actual time; for example those who started by adding 13 hours 35 minutes and got to 34 75, then changed this to 35 15 and then 11 15. Candidates who did not use this approach often became muddled and ended up with an incorrect time and/or an incorrect day with no opportunity to gain any interim working marks. Mistakes were often made when dealing with midnight; 01 15 was a common incorrect answer resulting from losing an hour by counting 24 00 when adding either the flight time or the time difference. Some candidates split the time up to midnight and after midnight, an efficient strategy which was often carried out successfully, but also caused confusion about when to add and when to subtract, leading to errors. Conceptual errors involved subtracting 15 hours rather than adding and occasionally subtracting the flight time. Some candidates omitted the day from the answer line and Saturday 23rd was also common. The correct day and date was, however, often the one mark gained by candidates who had made errors in the time calculations. **Part (b)** was much better attempted with very few candidates who did not score the mark. Candidates should remember that if an answer is exact, then they should give the full answer and not round it. Some candidates were rounding the answer to 3 significant figures but the full answer was often seen within the working to gain the mark. Candidates would occasionally divide by the exchange rate rather than multiply.

Question 3

The vast majority of candidates answered this correctly, demonstrating an efficient use of the calculator. With little working shown, it was difficult to see where candidates who did not gain the mark went wrong. From those who did show working, it appears that the errors were made in the denominator, either adding 0.2 or dealing with the cube root incorrectly.

Question 4

Stem-and-leaf diagrams appear to be familiar to the majority of candidates and a good understanding was demonstrated. In both parts, there was a minority who did not interpret the key, giving an answer in **part (a)** for example, of either $\frac{2}{2}$ or just 2. The vast majority were able to give the mode correctly in **part (a)**, although there was confusion between the median and the mode in a small number of cases. **Part (b)** was also well attempted. Some candidates did not know how to deal with the even number of data items and so gave an answer of 29 or 31 or both. Candidates should be careful with the use of the calculator here and put brackets around the two numbers being added before dividing by 2. Some candidates calculated the mean and those who did not interpret the key correctly calculated $\frac{9+1}{2}$ giving an answer of 5.

Question 5

Most candidates showed understanding that relative frequencies sum to 1 and indicated the sum of the 'lost' and 'drawn' was 0.9, usually resulting in full marks, although some did have the values in reverse order. Others had values that added to 0.9 which were not in the correct ratio, with 0.2 and 0.7 being the most common. A number showed the correct ratio of 2:1; the value of 'lost' as twice the 'drawn' value, but gave values that did not add to 0.9. $2x$ and x in the boxes with no other work was common. Another group of candidates calculated the value of 0.9 and used that as one of the answers and either doubled or halved 0.9 for the other value, hence 0.9 and 0.45 was regularly seen.

Question 6

The vast majority of candidates measured accurately and used the scale correctly to gain both marks in **part (a)**. One mark was also awarded, either for an inaccurate measurement (where perhaps the candidate was lacking a ruler) correctly converted or for an accurate measurement which was either not converted or converted incorrectly. The latter was often when candidates were changing kilometres into metres. Measuring a bearing continues to cause problems and **parts (b)** and **(c)** were not as well answered because of this. It must be emphasised to candidates that a bearing is measure clockwise from north and they must read the question carefully as to which point the bearing is measured from. Common incorrect responses in **part (b)** were 115°, 245° and 70°. Some candidates may have been lacking a protractor as there was a reasonably high rate of blank answer spaces. There were many correct points plotted in **part (c)** but it was plotting the bearing which once again proved difficult, with many candidates gaining one mark for plotting a point at 7 cm from *P* but on an incorrect bearing. It was common to see a bearing of 40° where the wrong scale on the protractor was being used and it was also common to see 140° measured in an anticlockwise direction.

Question 7

Most candidates understood what was expected of them for this question, both in terms of showing their working and giving their answer as a mixed number in simplest form. The most successful and most common strategy was to change $1\frac{5}{6}$ into an improper fraction, which meant that the whole number 1 was not forgotten at the end. Virtually all candidates understood that a common denominator was required and the value of 30 was almost always sensibly selected. Those who dealt with the whole number at the end sometimes left their answer as $1\frac{37}{30}$ but the more common way to lose the final mark was to leave the answer as the improper fraction, $\frac{67}{30}$.

Question 8

Candidates demonstrated a good understanding of simultaneous equations and those choosing the most efficient method of doubling the top equation and adding to eliminate y were by far the most successful. Many multiplied both equations in order to equate the coefficients of either x or y; perfectly valid methods but unnecessary, which often led to arithmetic and sign errors. Candidates should be very careful when dealing with negative values as it was very common to see inconsistent addition and subtraction of the terms. Many candidates rearranged one of the equations to make either x or y the subject and then substituted into the other equation. These candidates made far more algebraic and arithmetic errors following this. Candidates should be encouraged to check that their values fulfil both equations.

Question 9

Candidates demonstrated a good recall of the trigonometric ratios with the majority gaining both marks. Many candidates made extra work for themselves and often lost accuracy by using Pythagoras to find the third side and then using either sin or tan. Premature rounding of the cosine value also lost accuracy and so candidates should be encouraged to process the whole calculation in one go rather than re-type numbers into their calculator. A few candidates wrote down the correct method but then did not know how to use the inverse function to find the angle.

Question 10

The most successful strategy in this question was to find the exterior angle and then divide this in to 360 and centres should encourage this method when finding the number of sides. Many candidates could get no further than finding the exterior angle of 6 and many left the answer space blank. The majority of candidates who did not score any marks on this question used the interior angles formula incorrectly. The equation $180(n-2) = 174$ was seen many times, instead of $180(n-2) = 174n$. As a result, an inappropriate answer of 2.97 or 3 sides was extremely common. Some of those who did state the correct formula were unable to manipulate it to get to the correct answer.

Question 11

A full range of marks was awarded for this question with a good proportion giving the correct equation. A large number were awarded 2 marks for giving an answer in the form $y = mx + c$, with either the gradient or the intercept correct, more commonly the latter. Many gave an incorrect gradient of either –5 or $-\frac{1}{5}$. It was common to see the point (0, 6) substituted into the equation in order to find the intercept of 6. Weaker candidates rearranged the given equation to make x the subject, or simply reversed the signs and many did not attempt the question.

Question 12

Most candidates struggled to understand the concept of this question. Had they made up a starting value to provide more of a context, I am sure that many more would have got to the correct answer. One mark was frequently given for 100 – 35 or its equivalent. 100 + 40 was seen far less frequently and 0.65 × 0.4 was often calculated. Some candidates gained 2 marks for reaching 91 per cent, but then did not make the final step of subtracting this from 100. A large proportion of candidates were adding or subtracting the percentages and 5 was a common answer, either from 40 – 35 or (65 + 40) – 100.

Question 13

There were many completely correct answers to this inequality and a large number were awarded 2 marks for correctly dealing with the algebra but dealing with the inequality incorrectly. Those who kept the unknown positive on the right-hand side, usually went on to the correct answer but the majority of those who moved the unknown to the left-hand side ended up with $-14x \geqslant -14$ followed by $x \geqslant 1$. There were fewer candidates than in previous sessions who ignored the inequality sign and put $x = 1$ or just 1 on the answer line. Successful candidates usually made the first step of multiplying by 5 and then went on to isolate the terms in x. The most common algebraic mistake was to write, for example, $5 \times 4 - 3x \geqslant 6 - x$, followed by $20 - 3x \geqslant 6 - x$. There were some sign errors when isolating x terms and weaker candidates jumped straight to adding x before they had dealt with the fraction.

Question 14

Candidates should ensure that they read the information in proportion questions very carefully, as the majority of errors came from setting up the incorrect relationship at the beginning of the working. It was often seen as a direct relationship or without the square root or without the –2. Those that set up the correct relationship and worked step by step to find a multiplier first, often went on to gain full marks. The final step of evaluating x caused more problems than in previous sessions, with a large number of candidates scoring both method marks but not the answer mark. Difficulties occurred in the algebraic manipulation of isolating x, due to it being within the denominator and within a square root. Those multiplying by $\sqrt{x-2}$ first, in order to remove it from the denominator, fared much better than those who squared first, when 18 was commonly not squared. Weaker candidates had no strategy to deal with this question, showing various calculations involving the numbers given.

Question 15

Only very able candidates gained marks on this question. The vast majority took no account of the fact that the ratios were given for the heights and that the question asked for the ratio of areas and so did not score any marks. Those who did understand that the height ratios should be squared usually scored 1 mark for this by showing 25 or 64. Very few candidates appreciated the need to subtract the small unshaded area from the shaded area or to subtract the shaded area from the large unshaded area. Most did nothing with the 5 for the shaded area, and for the unshaded, added the 8 and 1; hence the answers 5:9 and $\frac{5}{14}:\frac{9}{14}$ for those using the length scale factors and 25:65 simplified to 5:13 for those using area scale factors were very common. Some did score 2 marks for 25 – 1 but very few could get to 64 – 25 + 1.

Question 16

It was common to see the next term in the sequence given as the answer in both parts of this question, even after an attempt, correct or incorrect, to find the nth term. A minority of candidates scored full marks in either part of the question but many part marks were scored in both. In **part (a)** there were many who started with a correct strategy of looking at differences. Some stopped at the first or second step but many did get to a constant third difference and scored a mark. Some connected this to a cubic expression but the majority attempted to find a linear or quadratic sequence using 6 as the starting point. Many used the same strategy of differences for **part (b)** which led nowhere. A good proportion of candidates scored the mark for the correct numerator of $n + 1$. Many were clearly familiar with geometric sequences and could also apply the general formula to find the nth term for the denominator. The term-to-term rule of multiplying by 4 was often spotted and some scored a mark for 4^n, although most translated this to $4n$ or sometimes n^4.

Question 17

A full range of marks was scored in this 4-step rearrangement. It was a minority who scored all 4 marks but the majority made the correct first step of multiplying by $1-x$. Weaker candidates did not know what to do from here and often started to add or subtract terms from within the bracket. Many did successfully multiply out the brackets but then proceeded to either add yx to give $y =$… or they rearranged to give $x =$… but where x was also a term on the other side of the equation. Candidates who isolated the terms involving x generally realised that they needed to factorise and went on to divide correctly. Some candidates made errors with signs when isolating but could still gain 3 marks for a correct factorisation and division. As mentioned in the general comments, this question was an example where candidates combined two lines of working which often rendered a correct line of working as incorrect after 'cancelling' or attempting inverse operations. Clear line by line working should be encouraged.

Question 18

Candidates demonstrated a good understanding and recall of using the sine formula for the area of a triangle and the majority scored full marks. Some broke it down into two parts, using $800 \times \sin 30$ to find the height of

400 and then using $\frac{1}{2}$ base × height to find the area, and with no rounding issues, this caused no problems. There were some rounding issues for those who split the triangle into two right angled triangles unnecessarily and worked with each triangle separately. A number of candidates incorrectly applied bounds to the measurements, perhaps because the question asked for the greatest number of houses. Some candidates did not score because they used cos rather than sin in the formula. The most common misconception was to treat the triangle as right-angled at *B*, with many correctly using the cosine rule to find length *BC* and then incorrectly calculating the area as $\frac{1}{2}$ 800 × *BC*. Others used the perimeter of the triangle after calculating *BC* and divided this by 400.

Question 19

Candidates clearly understood the method involved here and the most common score awarded was 2, for correctly setting up a single fraction or two fractions with a common denominator. It was a minority who then went on to simplify this correctly for the final mark. The very common error was to multiply out the brackets but only have a subtraction sign for the first term, hence adding the other terms. Candidates must be very careful when dealing with brackets, both with signs and ensuring that they are inserted where necessary. As in **Question 14**, brackets were often omitted and not recovered, for example $x+3(x+2)$ and $x+3\ (7)$. It was reasonably common to see candidates immediately crossing through the $(x+3)$ in the second term of the numerator and the denominator and this is a misconception for centres to address. A less common error was to change one or both of the signs in $x+2$ or $x+3$ to a negative, presumably because of the subtraction. Weaker candidates had no strategy to deal with the fractions and many simply added the numerator and the denominator as a first step.

Question 20

It was a minority of candidates who gained all 3 marks for giving both values of *x* as a final answer. It was extremely common to award 2 marks for the answer of 109. It would be beneficial for candidates to draw a quick sketch of the trigonometric function they are working with, in order to see the number of solutions and how to find them. Many of those who did recognise that there was more than one solution added 180 to 109. The majority of candidates who correctly rearranged the equation to cos $x = -\frac{1}{3}$ went on to gain the mark for the angle 109, although some seemed to lose the negative sign, either carelessly or intentionally to give an answer of 70.5. Weaker candidates struggled to make cos x the subject of the equation and it was common to see cos $3x$ rather than 3 cos x.

Question 21

Most candidates made an attempt at this question with a full range of marks awarded. A large proportion identified the correct triangle containing angle *ECO*. It would be advisable for candidates to draw and label the correct triangle as many angles marked on the diagram were ambiguous and could not score a method mark if they then continued incorrectly. Those who had identified the correct triangle usually went on to use the correct trigonometric function of tan $\frac{9}{OC}$. Some used the inefficient method of finding *EC* and then used sin or cos to find the angle, adding an extra unnecessary step which often led to inaccuracy due to rounding. Premature rounding was an issue throughout this question and centres should continue to remind candidates about this. $\sqrt{50}$ was often rounded to 7.1 and then halved to 3.55, sometimes without showing working and so marks could not be awarded as the value was incorrect and no working could be seen. Many candidates gained marks for finding the required length of either *AC* or *OC* but then could not progress to find the correct angle. A large number of candidates assumed a length of 2.5 for *OC* and so could only be awarded a maximum of one mark if they were attempting to find the correct angle. Those not scoring were generally using the wrong triangle, often *EBC* and attempting to find angle *ECB*.

Question 22

Candidates demonstrated a good knowledge of the basic laws of indices in **parts (a)** and **(b)** with a good proportion getting the correct answer to these parts. Of those with a correct strategy in **part (a)**, were some who did not score because they gave the answer –2 or did not fully simplify, leaving the answer unprocessed as $x^{-\frac{6}{3}}$. A common error made by those who did not know how to deal with the indices was to cancel the 3s from the denominator of each index and give an answer of $x^{\frac{1}{4}}$. Successful candidates in **part (b)** wrote out each side of the equation as a power of 2 or 4, although it seems that some successfully used a trial and improvement approach using a sensible starting point. Some lost the answer mark by converting to a decimal and not giving the answer to 3 significant figures which is required if inexact. Others left the fraction as $\frac{1}{1.5}$, also not an acceptable form. The answer of $\frac{1}{4}$ was reasonably common, presumably from the fact that $64 \div 16 = 4$. There were many candidates producing concise, elegant solutions in **part (c)**. The most common method was the expected method of changing the base of $\frac{1}{9}$ into base 3 in order to equate the indices, although other equally valid methods were seen. Some candidates worked out that the value of x was 1 but negated this with clearly wrong working trying to make the answer fit and sometimes it did, only because the value of x was 1. Clear errors were for example, to simply remove the $3x$ from both indices, multiply out the 9, divide incorrectly by 3, write $\frac{1}{9}$ as 0.111…, combine the indices as given and so on. There was a high no response rate for this question along with those who simply rewrote the question.

MATHEMATICS

Paper 0980/31
Paper 31 (Core)

Key messages

To be successful in this paper, candidates had to demonstrate their knowledge and application of various areas of mathematics. Candidates who did well consistently showed their working out, formulas used and calculations performed to reach their answer.

General comments

This paper gave all candidates an opportunity to demonstrate their knowledge and application of mathematics. Most candidates were able to complete the paper in the allotted time. Few candidates omitted part or whole questions. Candidates generally showed their workings and gained method marks. Centres should continue to encourage candidates to show formulas used, substitutions made and calculations performed.

Candidates find 'show that' questions challenging and often do not show all steps needed. Candidates should be reminded that to gain credit on these types of questions they must not use the fact they are trying to show.

Candidates should also be encouraged to process calculations fully and to read questions again once they have reached a solution so that they provide the answer in the format being asked for and answer the question set.

The standard of presentation was generally good; however, candidates should be reminded to write their digits clearly and not to overwrite their initial answer with a corrected answer but to re-write.

Comments on specific questions

Question 1

(a) (i) Nearly all candidates correctly identified 17 as the square root of 289. Occasionally a value was given that was not from the list. Answers were sometimes spoiled by candidates writing 17^2 and therefore not answering the question.

(ii) Some candidates gave factors of 81 that were not on the list, usually 9, but the vast majority were successful in identifying 27 as the factor of 81.

(iii) Again, the vast majority of candidates gave the correct answer of 30 as the common multiple of 3 and 5. Some candidates gave a common multiple of 3 and 5 which was not in the given list, usually 15. Some others gave 25 or 27 as multiples of 5 or 3, rather than a common multiple.

(b) Few candidates gained full credit in this question. A number of errors were seen including 1 as a prime number, three correct values but not consecutive or square and cube numbers in the wrong places. Whilst most candidates were able to gain partial credit by satisfying at least two of the criteria, few found three consecutive numbers which fitted the criteria. The use of indices for the cube and square numbers (such as an answer of 2, 3^3, 4^2) showed misunderstanding of what was required. Successful candidates wrote a list of prime, cube and square numbers to then pick the three suitable numbers from their lists.

(c) (i) The majority of candidates successfully placed one pair of brackets in the correct place in **parts (i)** and **(ii)**. Errors were uncommon but those that did occur included ÷ or ÷ 2 inside the bracket.

(ii) Occasionally two sets of brackets were seen around 51 – 12 and 3 + 6.

(d) (i) Many candidates did not understand the term 'reciprocal' leading to varied answers. Some answers showed that they had an idea, such as 8/1 or –8. Other common errors were to give the cube root or the square of 8.

(ii) Finding the value of 14^0 was usually answered correctly, with 0 or 14 seen occasionally.

(e) (i) Nearly all candidates correctly used their calculator or showed understanding of indices to reach the correct answer of 625.

(ii) Again, this part was well answered by candidates using their calculators, although not as successful as **part (e)(i)**. A common incorrect answer was $\left(3\times\sqrt{6859}=\right)248.457...$

(iii) Fewer candidates were able to calculate with a negative fractional index number. Common incorrect answers came from misreading the question as $16-\frac{1}{2}=15.5$, interpreting the power as halving with a common incorrect answer of 8, or not interpreting the negative index number correctly with the common incorrect answer of –4.

Question 2

(a) Most candidates demonstrated their understanding of place value and place holders well on this question. Unsuccessful candidates often missed out the zero in the hundreds column (49 650) or treated the given number as two separate numbers, i.e., 496 000 50 or even three separate numbers, i.e., 400 96000 50, along with other variations.

(b) (i) The vast majority of candidates achieved the mark for 'Musicals' but fewer scored the mark for the angle. Some wrote the incorrect angle on the answer line while indicating the correct angle on the diagram. Some candidates may not have had a protractor as they left the angle blank or appeared to be trying to calculate it. Only a few referred to a different sector of the chart.

(ii) This part was quite well attempted but 90% was a common error, confusing degrees with percentage. Some gave 27% presumably from the Operas angle. Many candidates chose to calculate that an exact quarter of the circle represented 25%, e.g. $\frac{90}{360}\times100$.

(iii) Many candidates were successful in calculating the number of opera performances as 24. Most correct answers found the fraction of the pie chart and then multiplied by 320. There was some confusion between percentages and degrees in pie charts from some candidates. Some chose to work out the percentage that represented opera, 7.5%, but either did not know what to do with that or did not make it clear that it was a percentage. Many incorrect approaches were seen such as expressing their fraction of opera performances out of 320 instead of 360 (giving 30.375) or found 27% of 320 or 320 ÷ 27 = 11.85.

(iv) Candidates found this part more challenging. Many used the usual ratio method of adding the values in the ratio (12) dividing 56 by the total (4.666...) and then multiplying by 5 (23.333). These candidates had not appreciated that the 56 was the number of classical music concerts and not the total number of concerts.

(c) Candidates showed good understanding of working with money with successful solutions showing every step of their working out. Many candidates used a correct method to reach 78 but did not halve it whilst others did not include the fact that Alex was buying for 3 children not just 1. Other candidates made errors with arithmetic when rearranging their equation.

(d) Calculating the percentage reduction was well attempted with most candidates gaining at least partial credit. The most common correct method was to calculate the reduction first (9.10) and then divide by the original cost (65) and finally multiply by 100. Common incorrect answers were 86 (55.90 as a percentage of 65) or the use of the incorrect fraction $\frac{9.1}{55.9}$.

Question 3

(a) Almost all candidates calculated 64 and 160 correctly but many had difficulty with a column or row with two missing values. In these types of questions candidates must be very careful as a single arithmetic mistake can result in other values being incorrect.

(b) (i) Candidates were less successful in using the table of results to calculate the probabilities in all three parts of **(b)**. Candidates often gave all three answers out of 360 rather than the correct denominators as identified by the wording in the question. In this part there were many incorrect answers, with $\frac{62}{121}$ the most frequent incorrect answer from using the total for the Wildlife Centre instead of the total Girls. Some converted a correct fraction to a decimal with less than 3 significant figures without showing that fraction first.

(ii) The correct answer was seen often as $\frac{9}{24}$ or its simplified form $\frac{3}{8}$. Many candidates gave the denominator as the grand total, so $\frac{9}{360}$ was often given as the answer. Another incorrect answer seen was $\frac{9}{163}$ using the subset of Girls.

(iii) Successful candidates added the number visiting the Adventure park and Botanic gardens before forming a fraction or added two separate fractions to reach $\frac{168}{360}$. Common incorrect methods included $\frac{144}{360}\times\frac{24}{360}\left(=\frac{2}{75}\right)$.

(c) Around half of the candidates correctly found the number of coaches (3) and the number of empty seats (12). This was either done by dividing 144 by 52 or by repeated addition. A common incorrect answer was 2,40 from $\frac{144}{52}$ being 2 remainder 40.

(d) (i) Candidates found writing an expression challenging and often wrote an equation instead. $550 + 1.12x = 551.12x$ and $x = 550 + 1.12x$ were seen often.

(ii) Only the most able candidates could equate their expression with the given expression and then solve correctly. Some candidates who were unable to get to the correct answer could often equate the expressions for the two companies and start to rearrange them. Some simply added the two expressions. There were many attempts to use simultaneous equations by equating both expressions to y, but these attempts generally did not prove successful. Some candidates were able to find the correct value of 125 km through trial and improvement.

(e) There was a great variety of answers. Around half of the candidates did give the correct answers but of those who did not, a few got the numbers the wrong way around or rounded to whole numbers giving, e.g. 52 and 53 or 54. Others gave the answers correct to the nearest 100 m or 200 m not the nearest kilometre as required by the question. 53.4 as the upper bound was seen only a few times.

(f) (i) This part was the most successfully answered part of this question. Most candidates correctly found the amount spent to be \$9. Common errors seen were converting $\frac{2}{7}$ to a percentage and then finding 28.6% or 28.5% or 29% of 31.50 and therefore not giving the correct level of accuracy needed.

(ii) Around half the candidates were able to give the correct fraction as $\frac{6}{7}$. Some started correctly by doing $\frac{4.50}{31.50}$ and getting as far as $\frac{1}{7}$ to give the fraction left, but then not subtracting it from 1 to give the fraction spent as stated in the question.

Question 4

(a) (i) The majority of candidates correctly identified angle *a* to be 48. Common incorrect answers were 132 (answer to **part (ii)**) and 72.

(ii) Fewer candidates were able to identify angle *b* to be 132. Common incorrect answers were 48 (answer to **part (i)**) and 84 (180 – 48 – 48).

(b) Many candidates correctly found *x* to be 74, the most common successful method being 360 – 72 – 119 – 63 = 106 and then 180 – 106 = 74. A significant number of candidates gave the final answer of 106 as they did not complete the full method. Other common incorrect answers were 108 (180 – 72), 63 (incorrectly using alternate angle with angle *BCD*) and 72 (incorrectly using corresponding angle with angle *BAD*).

(c) (i) Many of the candidates correctly named the line *BC* as a chord. The most common incorrect answers given were radius and tangent.

(ii) Explaining why angle *ABC* is 90° proved to be a challenging question. Candidates must use correct terms from the syllabus - '*Angle in a semicircle is 90°*'. Many candidates gave longer answers which included terms like diameter and chord.

(iii) Finding the value of *x* was equally as challenging and only the most able candidates found the correct answer. A number of incorrect assumptions were made by candidates about the triangles *ABO* and *BCO* which led to incorrect answers. First was that angle *CBO* and angle *ABO* were equal and therefore 45° each which often led to the incorrect answers of 91 or 89. The other assumption was that triangle *ABC* was isosceles and therefore angle *BCA* was 46° which often led to the incorrect answer of 88. Other incorrect answers seen were 90 (often with little or no working out – assuming angles *COB* and *AOB* were equal) and 44. Candidates should be encouraged to write known or calculated angles on the diagram.

(iv) More candidates were successful in finding angle *y* to be 44°. Successful methods used correct right-angled triangles *BCD* or *ACD*. Some candidates incorrectly assumed that triangle *BCD* was isosceles.

Question 5

(a) The majority of candidates were able to find the range. Many candidates showed they understood that range was the difference between two values but used 2 and 13 (first and last values in the table) or 25 and 20 (television not social media). A large proportion of candidates attempted to find the mean or median instead of the range.

(b) (i) Many less able candidates did not attempt this part despite answering all the other parts. Of those that did answer many were accurate when plotting the points. However some were in the incorrect place because of plotting them the wrong way around (up first then across). Others were just one square out because of misreading the scale, especially horizontally. Many candidates only plotted one of the points correctly.

(ii) More candidates recognised that this diagram showed negative correlation and some qualified it with weak or strong. Incorrect answers such as descending or inverse were seen. A small number of candidates recognised it was about correlation but incorrectly gave it as positive.

(iii) Many of the attempted lines of best fit were acceptable. Lines which were not accepted were generally too steep or no single line drawn. Many candidates joined the points.

(iv) Candidates' answers were often within the acceptable range even from an incorrect or no line. Several follow through marks were awarded for answers outside of the range using their line of best fit.

Question 6

(a) (i) To be successful, candidates had to explain that the train had stopped moving. This could have been given in a variety of ways including stationary, at rest or at Wengernalp.

(ii) Most candidates were able to read off the times that the train left Allmend (13 59) and arrived at Wengernalp (14 09). However not all were then able to give the correct answer of 10 minutes. Common incorrect answers were 11, 25 and 9.

(iii) Most candidates realised the need to use the speed distance time formula. The correct formula was quoted often and successful candidates used the correct distance of 6.4 m and time of 25 minutes which they either correctly converted to hours as $\frac{25}{60}$ or $\frac{5}{12}$ hours. Candidates who converted their time to hours but rounded to 0.417 or 0.416 often did not gain full credit as their final answer was not exactly 15.36. Many candidates divided 6.4 by 25 but did not then multiply by 60 to give their answer in km/h. Many candidates were unable to find the correct time from the graph with 24, 19, 14 and 29 seen often or the actual time of day 14 19 used.

(iv) A large number of candidates did not attempt the drawing of the journey for the second train. Those that did often gained partial credit for the final two parts of the journey (14 18 to 14 30). However many were unable to gain full credit as they either did not start at the correct position, with (14 01, 6.5) plotted instead of (14 01, 6.4), or the end of the first part of the journey finished at (14 18, 2) instead of (14 18, 1.9).

(v) Most candidates were able to identify the time that the two trains passed each other from their intersecting lines on the graph. Many candidates gained this mark as a follow through from an incorrect line in **part (iv)**.

(b) Candidates demonstrated good understanding of negative numbers with the vast majority correctly giving the temperature as 7. Common incorrect answers were 13 and −13.

(c) Some candidates found this substitution question challenging although the vast majority did get the correct answer of −4.

Question 7

(a) (i)(a) Many candidates were able to identify *C* and *G* as the two corners which join to corner *A*. Common errors were *G* and *H*, *F* or *N* or pairs with *B*, *M* or *N*.

(i)(b) Many candidates were able to identify the edge which joins with *KL*. Common errors were CD, *MJ* and *IN*.

(ii) The most successful solutions showed the area of all 3 different rectangles and then adding 6 values or doubling and adding 3 values to reach the correct answer of 76 cm². Some candidates however found it difficult to find the 3 separate dimensions from the net and various attempts at incorrect rectangle areas were seen. Some candidates used the formula for the volume in this part. Few candidates counted squares from the net (those that did generally got it correct).

(iii) Fewer candidates were able to find the volume than the surface area with a significant number of candidates not attempting this part. Successful solutions showed the formula and full working out to reach the correct answer of 40 cm^3. Common errors came from using one incorrect dimension from the net, e.g. $5 \times 4 \times 4 = 80$ cm^3 and $4 \times 4 \times 2 = 32$ cm^3.

(b) (i) Good solutions often came from quoting the correct formula for the volume of a cylinder and then substituting in 3.2 for *r* and then rearranging to find *L*. Common incorrect answers came from wrong formulas used for the volume of the cylinder or the area of the circle. Many less able candidates simply divided the volume by the radius.

(ii) Candidates were given the formula for the volume of a sphere and therefore were more successful in this part than the other two parts in **Question (b)**. Few candidates did not attempt it and most were able to gain at least partial credit for a correct substitution of 3 for *r*. Some candidates showed the correct substitution but then squared instead of cubed and gave a common incorrect answer of 37.7.

(iii) This challenging percentage and volume question was not attempted by some candidates. Only very able candidates gave the correct answer. Successful solutions were carried out in steps with full working shown. Candidates generally started by multiplying their answer to **part (ii)** by 4 and then subtracted this from 775. The full method required a percentage so this value had to be divided by the total volume of the cylinder and multiplied by 100. Common errors included not subtracting from 775 (finding the percentage not empty), dividing by an incorrect value and not multiplying by 4. Some candidates thought they needed to find the largest number of spheres that could fit in the tube and therefore did not multiply by 4 (often by 6).

Question 8

(a) (i) Whilst most candidates recognised this was a Pythagoras' theorem question about finding a short side and therefore involving a subtraction, some were unable to show clearly each step leading to the answer of 75. Often candidates did not explicitly show the subtraction. Few candidates who attempted a trigonometric solution got all the way to the end. Only a few started with 75 and therefore did not 'show that' it was 75. However, there were many fully correct answers showing the required squares, subtraction and square root.

(ii) This part was less well attempted with only a minority gaining credit. Many did not recognise this as a trigonometry question and many who did often used the incorrect sides with the trigonometry ratio or wrote them upside down. A common error was to use $\sin^{-1}\left(\frac{100}{125}\right)$. Premature rounding was an issue for some and others rounded their final correct answer to 36.8 without showing a more accurate answer. Possibly some did not know how to do the inverse of a trigonometric function on a calculator. Others did not use trigonometry, giving answers of 45, 90, etc.

(b) Some candidates found this question challenging and tried to use trigonometry, Pythagoras' theorem, or various combinations of adding and subtracting the given numbers. Candidates who found the correct area, 96, of the lower triangle often went on to gain full credit. 192 was a common incorrect area with the candidate forgetting to divide by 2 for their triangle. A significant number of candidates did not attempt the question.

Question 9

(a) (i) Many candidates were able to correctly rotate triangle *A*. However, a large proportion of candidates were able to gain partial credit for rotating triangle *A* 90° clockwise but about the incorrect centre; common incorrect centres were (3, 2) or (3, 5).

(ii) Many candidates were able to correctly reflect triangle *A* in the line $x = 5$. Common errors were to reflect in the line $x = 4$ or $x = 0$.

(iii) This enlargement question proved to be the most challenging of the three transformation questions. Only a minority of candidates were able to enlarge correctly in the correct position. Many candidates did however gain partial credit for a correct size and orientation but in the incorrect place, often using (7,7) as the point for the right angle rather than the centre of enlargement.

(b) Many candidates gave the correct description. Common incorrect vectors given were $\begin{pmatrix}7\\2\end{pmatrix}\begin{pmatrix}2\\-7\end{pmatrix}\begin{pmatrix}7\\-2\end{pmatrix}$. Translocation was the most common incorrect answer instead of translation.

Question 10

(a) Completing the table was the most successful part of this question. Nearly all candidates attempted the question and a majority were fully correct. Substituting a negative value of x (–2) into a quadratic expression challenged some candidates. The common incorrect answer was 2 or –2 for $x = -2$.

(b) There was good plotting of points with smooth curves drawn and very few straight lines joining points were seen and even fewer thick or feathered curves drawn. Common errors were joining (1, 6) and (2, 6) with a straight line and plotting point (–1, 0) at (0, 0) or (0, –1).

(c) In this question candidates were asked to solve an equation by using their graph, which most candidates did not realise that they simply had to read the x-coordinate of the points of intersection of their curve and the given straight line. –1 and 4 were the most common incorrect answers given from solving the quadratic = 0. Candidates who attempted to give the points of intersection often gained partial credit for the positive value between 2.7 and 2.9 although the negative value was less successful with many answers less than –2 given.

MATHEMATICS

Paper 0980/41
Paper 41 (Extended)

Key messages

To achieve well in this paper, candidates need to be familiar with all aspects of the extended syllabus. They need to be able to recall and apply mathematical formulae in structured questions as well as interpret situations mathematically in unstructured questions. Some candidates may have achieved more highly by taking the Core papers.

Work should be clearly and concisely expressed with answers written to an appropriate degree of accuracy. It is important that candidates retain at least 4 figures in their intermediate working to ensure that final answers are correct to three significant figures or better. Accuracy marks may be lost if candidates round prematurely in their working or if answers are not given correct to at least three significant figures.

Candidates should show full working on the question paper to ensure that method marks are considered where answers are incorrect. Method marks may not be gained if working with only 2 significant figures. Candidates should write down any intermediate step that they may have done with a calculator. Rough paper should not be used.

In questions where a level of explanation is needed candidates should use the terminology as described in the syllabus rather than trying to describe, for example, a cyclic quadrilateral.

Candidates should avoid writing in pencil and then overwriting in pen as solutions can become illegible.

Candidates should take sufficient care to ensure that their digits from 0 to 9 can be distinguished.

Candidates should ensure that their calculator is set in degrees.

General comments

Many candidates demonstrated their understanding of a wide range of mathematical concepts and were able to apply them in structured questions. The unstructured question parts were more challenging for candidates, as was the question on finding the equation of a tangent using differentiation, an addition to the syllabus in 2020.

The majority of candidates indicated their methods with clarity but some candidates gave answers with no working and subsequently could not gain partial marks. A significant number of candidates showed minimal working. This sometimes resulted in 'near miss' values which, with no supporting evidence, do not receive credit. Some candidates are using the ratio symbol for division and unconventional 'crossing arrow' notation without ever forming an equation. This approach is often insufficient to gain partial marks.

Candidates seemed to have sufficient time to access all questions.

Most candidates followed the rubric instructions with respect to the values for π although a few used $\frac{22}{7}$ or 3.14, which may give final answers outside the range required.

Candidates should expect to give final answers as a numerical value rather than a complex fraction or expression involving π unless the question requests a particular format.

The topics that proved to be accessible included: using proportion to find costs in a practical context, increasing by a percentage, exponential increase, finding an estimate of the mean from a grouped frequency table, constructing and solving linear equations and using the quadratic equation formula. Also use of circle theorems, plotting points and drawing unfamiliar graphs.

More challenging topics included: Reverse percentage, calculating with upper and lower bounds, combined probability without replacement, factorising a quadratic with co-efficient of x^2 not equal to 1, difference of two squares, geometrical reasoning using correct vocabulary to support angle calculations, manipulation of an equation to cubic form, position vectors, completing the square and sketching curves and finding the equation of a tangent making use of differentiation. Candidates also sometimes struggled to identify the appropriate technique in unstructured questions.

Comments on specific questions

Question 1

(a) (i) This question was generally well answered with most candidates understanding the concept of surface area. Errors seen included calculating areas of only some of the rectangular faces or calculating volume. The sum of the edges of the cuboid was also occasionally seen.

(ii) This was also generally well answered with most candidates multiplying a correct volume by the density, however, many of these candidates did not correctly conclude by converting grams into kilograms. Some other candidates carried out a correct conversion but reduced it to two significant figures. A few candidates had a correct volume calculation but did not use the given density formula correctly. A small number of candidates used the surface area from **part (i)** instead of the volume.

(b) This was very well answered. The only challenge appeared to be dealing with the 200 and the $175 to find the cost of one brick, where 200 was occasionally divided by 175. A small number of candidates gave the cost for one house only.

(c) This proved to be a more challenging question with the context of hours worked, days worked and the starting date. There were many correct answers, and many candidates reached the value of the number of days to be 4.166.... A number of these candidates gave the answer of July 11th, thinking that the work started after July 6th as opposed to on July 6th. A smaller number of candidates rounded the number of days to 4 and gave the answer of July 9th.

(d) There was a mixed response to this question part with some candidates having difficulty recalling and applying the formula for the volume of a cylinder. Some candidates used the formula for volume of a cone while others did not associate capacity with volume and instead used area formulae. The conversion from cubic cm to litres was often either incorrect or overlooked. A few candidates treated the given diameter as the radius.

Question 2

(a) (i) Many candidates found this question part difficult. A common error was to work out $\frac{5}{16}$ or $\frac{7}{16}$ as a percentage, due to working out Chao's or Mei's time as a percentage of the total. Some candidates knew what to do but gave their answer as 71 correct to two significant figures, rather than giving at least three significant figures. A small number of candidates found both Chao's and Mel's time as a fraction or percentage of the total and then correctly divided these two answers, rather than using the efficient approach of $\frac{5}{7}\times 100$.

(ii) Most candidates knew that they needed to work with a time and divide by 4 then multiply by 7. Some candidates had success by initially changing Bob's time to seconds, avoiding the need to process minutes and seconds. Some candidates used a fully correct method having rounded a decimal version of 55 minutes and 40 seconds. The error 55.4 was often seen, as was premature rounding to 55.7 or truncating to 55.6. Working separately with the minutes and seconds was a useful method for some candidates, although errors were made when reconverting to minutes and seconds. Another approach was to find the total time and then find the correct fraction of this for Mei's time. Candidates who showed each stage of working were able to pick up some marks, even if they calculated Chao's time.

(b) (i) This question part was well answered. Most candidates used the multiplier of 1.28 to directly obtain the answer. The main errors were candidates just finding the increase, division by 28, or use of 72 per cent.

(ii) This percentage calculation proved to be difficult for many candidates. Many thought that 47.50 was 60 per cent of Mei's money rather than 40 per cent. This resulted in many candidates stating $\frac{47.5}{0.6}$ rather than $\frac{47.5}{0.4}$. Other candidates did not see the question as requiring a reverse percentage calculation and found either 40 per cent or 60 per cent of 47.50 as an incorrect first stage and frequently 160 per cent of 47.50.

(c) This proved to be a challenging question part and many candidates achieved only partial success. The best solutions realized that they had to find the limits of the ranges of the two values and then combined these values using the minimum for 11.2 divided by the maximum for 70. Choosing this combination and with the need for consistent units was demanding for most candidates. The main errors with finding the upper and lower bounds were 11.2 given as 11.1 to 11.3 and 70 given as 65 to 75. A significant number of candidates did not recognise that it was a bounds question at all and calculated 1120000 ÷ 70. Amongst the minority of candidates who had the correct method were those who gave the answer 15379.3 or rounded their answer to 3 significant figures, not realising what was required in the context of the question.

(d) Almost all candidates understood how to efficiently use exponential increase. The main error was to write out their answer in full rather than giving an answer in millions. A small number of candidates used the correct but inefficient method of separate calculations for each year but usually worked with sufficient accuracy. A small minority of candidates used simple interest, others decreased by 2.4 per cent or spoilt their method by continuing to subtract 1.6 million from the amount raised by the charity in 2020.

Question 3

(a) The construction of a box-and-whisker plot on an in-line grid directly below the cumulative frequency diagram was required. This layout was used well by many candidates to produce an accurate plot, drawn using a ruler. Most candidates who knew that the quartiles were needed, drew them in the correct place. A significant minority of candidates were unfamiliar with a box-and-whisker plot.

(b) (i) There was a mixed response to this question part. The common error was to use 30 on the cumulative frequency to give an incorrect answer of 58.5 kg. Most candidates who understood to find 30 per cent of 80 first, went on to gain full marks.

(ii) This part was well answered with many candidates obtaining the correct answer. Others read 64 correctly for boys with a mass of 75 kg or less but did not then subtract from 80. Some candidates misunderstood the scale and 18 was a common incorrect answer, often after 62 was seen in the working.

(c) (i) A good proportion of candidates correctly calculated the missing values in the table.

(ii) This question part on finding the mean from grouped data was very well done. Those candidates who had incorrect values in **part (c)(i)** usually still earned method marks due to clear working shown. The most common error seen was from the minority who used an interval width of 10 instead of the mid-interval values.

(iii) This was a challenging question for many candidates, and it was rare to see the fully correct answer. Many candidates were able to score partial marks for $\frac{10}{24}$ or $\frac{14}{24}$ seen and others for the correct product $\frac{10}{24}\times\frac{14}{23}$, just omitting to multiply by 2. A common mistake was to multiply fractions with denominators of 80 and 79, not acknowledging that the two boys were chosen only from those with a mass greater than 70 kg. The other common error seen was the product $\frac{10}{24}\times\frac{14}{24}$. Almost all candidates showed the products of fractions that they used so that it was possible to award partial marks when appropriate.

Question 4

(a) (i) This question part was answered very well. Those candidates who expanded the bracket as their first step and then collected the terms together were the most successful in solving this equation. The minority of candidates who chose to divide by 6 first found this more problematic and made errors with both the fraction calculations and the signs when collecting the *x*'s together. Most errors seen were arithmetic when expanding the bracket, or sign errors in the collection of terms. Some candidates gave their answer as 3.3, which as a 2 significant figure value, does not gain full marks.

(ii) The candidates who were able to begin with $3\times 2x = 2(x-5)$ were often able to continue and solve the equation to obtain the correct answer of –2.5. Sometimes the bracket was omitted and $2x-5$ was common to see rather than $2x-10$. After the correct line $6x = 2x-10$ a common error that followed was to state $4x = 10$. Candidates who retained the fraction $\frac{2}{3}$, and attempted to solve $2x = \frac{2}{3}(x-5)$ found this more difficult. It was common to see the bracket omitted and fractions replaced by decimals, which caused further problems in the collection of terms.

(b)(i) Although the complete factorisation was seen by the most able candidates, many candidates saw only the common factor of 2 and obtained $2(x^2 - 144y^2)$, giving this as their final answer, or following it with $2(x-12y)^2$. For those who recognised the method of difference of squares, incorrect responses included $(x - 12y)(x + 12y)$ and $2(x - 12)(x + 12)$.

(ii) Many candidates found this factorisation of a quadratic a challenge. It was evident that a significant number of candidates used their calculator function, or the quadratic formula, to solve $5x^2 + 17x - 40 = 0$ and then attempted to work backwards from their solution. $(x+5)(x-\frac{8}{5})$ was a common wrong answer.

(c) For this question candidates needed to simplify and rearrange the given cubic equation to $4x^2 - 17x + 9 = 0$, and then solve using the quadratic formula. The use of the quadratic formula to solve a quadratic equation is well understood by most candidates and many set out their working with accuracy and clarity. It is acceptable to write $(-17)^2$ or 17^2 or 289 as part of the discriminant but a common error seen was to write -17^2. The error –17 at the start of the formula was also seen. Some candidates had a short division line writing $17 \pm \frac{\sqrt{17^2 - 4\times 4\times 9}}{2x4}$ which does not earn full marks even when followed by correct answers. A few candidates showed no working within the formula but arrived at correct solutions, which does not earn full marks as the question requires candidates to show all their working. Writing only $\sqrt{145}$ for the discriminant is not sufficient working. Most candidates gave their answers correct to 2 decimal places as required but answers to 1 dp or 3 dp were also seen. Some candidates made a sign error in re-arranging the equation at the start to give $4x^2 - 17x - 9 = 0$. Weaker candidates did not recognise that the cubic equation simplified to a quadratic.

Question 5

(a) (i) The majority of candidates were able to correctly calculate angle CBD as 62°. Giving a correct geometrical reason proved to be more problematic. Candidates are expected to use the correct vocabulary. Words such as middle, origin or angle O are not acceptable alternatives to 'centre'. Edge, top, bottom, at the point, are not acceptable alternatives to 'circumference'. Showing a sequence of calculations leading to 62° is also not a geometrical reason.

(ii) Many candidates showed good competency in using the isosceles triangle OCD and the sum of opposite angles in a cyclic quadrilateral to calculate angle BAD as 117°. Of those that did not reach 117, many were still able to demonstrate some knowledge by stating angle OCD = 28. The most common incorrect angle size for BAD was 63°, where candidates thought that opposite angles in a cyclic quadrilateral were equal. Giving sufficient geometrical reasons using correct vocabulary was once again problematic. Many candidates omitted to state that triangle OCD was isosceles. Candidates who attempted to state that opposite angles in a cyclic quadrilateral are supplementary often omitted 'opposite' or 'cyclic'. Others referred to opposite sides instead of angles or described a quadrilateral in, or inscribed in, a circle, which is not an acceptable alternative for 'cyclic'. As in **part (a)(i)** many felt that showing a calculation was the same as giving a geometric reason.

(b) This proved to be one of the more challenging question parts. Common misconceptions were that triangle SPR was isosceles and that SQ and PR intersected at 90°. This led to candidates working with incorrect right-angled triangles. Some candidates recognised angle SQP = 42° but did not progress by using angle SPQ = 90° as an angle in a semi-circle. Other candidates stated in error that angle RPQ was equal to 42 due to alternate angles. Candidates that worked with the right-angled triangle SPQ were usually able to reach a correct diameter and then the correct circumference, although prematurely rounding the diameter to 7.9, which led to an inaccurate value for the circumference, was seen from some candidates. Other candidates created the isosceles triangle POQ and used the sine rule successfully to find the radius. The error $C = \pi r$ sometimes followed.

Question 6

(a) (i) The majority of candidates correctly evaluated the three points. The most common errors were to give negative values for the points at $x = -3$ and $x = -2$ due, for example, to entering $(-3)^2$ as -3^2 on the calculator.

(ii) The plotting of points was usually accurate. Candidates typically plotted points at the correct vertical lines for the x values. The most common errors were the plots at $x = 0.2$ and $x = -0.2$ which were often incorrect by a complete small square. The curve was usually correct following their plots although some curves did not pass sufficiently close to the plotted points. Errors seen included using clear straight-line segments or crossing the y axis and joining the two separate branches.

(b) This was often left blank by candidates who did not see the need to draw the straight-line $y = \frac{24}{5} - 2x$. When drawn, the line was usually sufficiently accurate to lead to full marks. Some candidates drew a correct line but then mis-read the scale. It was common to see candidates not draw a line and use an algebraic method to try and solve the equation.

(c) The combination of the need to deal with denominators and rearrange proved difficult for many candidates. The most successful solutions had more than one stage to remove the denominators and then rearranged their equation to equate it to zero. This usually resulted in full marks unless a sign error was made in the rearrangement. Some candidates tried to work with decimal values for a, b and c as they could not make the link between the given equation and a cubic.

Question 7

(a) (i)(a) There were many diagrams drawn showing that candidates understood the idea of the scale factor of enlargement being 2 but they were less able to draw this enlargement using the centre (0,1). A variety of different centres appeared to be used.

(i)(b) This part proved quite challenging for many candidates, who were unable to begin by drawing the line $y = x - 1$ correctly. Common errors seen were to reflect in the line $x = 1$ or $y = x$. Some candidates who did draw the correct line were sometimes unable to accurately reflect across this diagonal line.

(ii) Most candidates recognised that the transformation was a rotation and many could give the angle as 90°, but there were many wrong centres of rotation given or no centre given at all.

(b) This part proved to be challenging for many candidates. For those who understood the steps they needed to take, there were errors in signs when finding vector AB or vector BA. This followed through their working to give incorrect results for other vectors. Even when correct vectors were found for AB or BA, using them to find BM or AM and subsequently a result for OM was found problematical when collecting the terms together. Most candidates would benefit from setting their work out in a clearer way, showing which vectors they are attempting to find. A number of candidates left this part blank and some who attempted it did not seem to appreciate that they needed to find vector OM.

Question 8

(a) (i) Forming the equation from a linear function equated to a given value was well answered. A common error seen was to substitute the value –5 into the function. Almost all candidates who set up the correct equation gained full marks.

(ii) The inverse of the linear function was also well answered. Any errors were usually sign errors, rather than a misunderstanding of inverse of a function. Almost all candidates started with *y* equal to the function and then a correct first step of either re-arranging or interchanging *x* and *y*. A flowchart approach is not advised as candidates struggled with the inverse of subtracting *from* 3, usually stating adding or subtracting 3. One misconception was to think that $f^{-1}(x) = \frac{1}{f(x)}$.

(b) (i) This completing the square question was very challenging. Many candidates struggled to cope with the negative sign of the x^2 term and many others simply found the topic demanding. There were few fully correct answers.

(ii) The sketching of the graph of the completed square equation was equally challenging. Some candidates aimed to sketch the correct parabola but need to take care to keep it smooth and symmetrical. Intercepts with the axes were not required but when found, the shape of the curve was often distorted to try to fit them. The candidates with a completed square expression often did not connect this to the turning point on the sketch. Some candidates chose not to use their answer to **part (i)** and used calculus to find the turning point. This was a lot of work for the marks but these candidates were more comfortable with calculus than they were with completing the square. There were few fully correct answers.

(iii) The stronger candidates found this calculus question about the equation of a tangent more accessible than completing the square. The topic is quite new to the syllabus but some candidates were very well prepared. Other candidates were less familiar with it and did not connect the question to calculus. There were a few slips with the signs when differentiating but the candidates who recognised that calculus was needed were usually able to connect the value of the derivative at $x = 4$ to the gradient of the tangent, although the error of equating the derivative to 0 and using this value of *x* was also seen. Candidates should use the correct notation for the derivative and avoid equating all expressions to *y*. Most candidates recognised the need to substitute $x = 4$ into the equation of the curve to find the *y* – coordinate and for several candidates this was the only mark achieved. A significant minority of candidates omitted this question.

Question 9

(a) The majority of candidates were able to set up and solve a correct linear equation in *x*. Occasionally numerical errors were seen when solving the equation but the most common error was to set up and solve $x + x + 3 = 20$. A minority of candidates confused area and perimeter and used $x(x + 3) = 20$.

(b) This question part required the application of the sine rule to an unfamiliar situation. Many candidates indicated on their diagram the correct side length of 5 cm for the rhombus but a minority were unable to recall this property of the rhombus and did not then progress. Many candidates were well prepared to use the sine rule, however they did not appear to consider using it to find the angle at M. Candidates focused on attempting to find the side opposite angle *y* first and a common error seen was to treat the given triangle as right-angled at *y* and use Pythagoras' Theorem with the sides of 5 and 2.5. This incorrect value for the side opposite angle *y* was then used in the sine rule to find angle *y* indicating some confusion. A less common error seen was to use the sine rule with angle *y* opposite side length 5. Candidates who correctly applied the sine rule to find the angle at M almost always continued to subtract this from 180º. Some candidates used the cosine rule to set up a quadratic equation in *x* for the missing side of the triangle, solved this correctly and chose the appropriate value for the side length to use in the sine rule, but then overlooked the information that *y* was obtuse and so gave the calculator value of 63.16 for *y*. Accuracy was also often lost in this inefficient method. This unstructured question part also proved to be a challenge. Most candidates understood to find r first and a significant number of these were able to set up the correct equation $2r + \frac{40}{360} \times 2\pi r = 20$. However, only a minority of these were able to manipulate this equation correctly to make *r* the subject. Other candidates used an approximated decimal for $\frac{40}{360} \times 2\pi$ but inevitably lost accuracy by using *r* = 7.4 in following steps. The most common error in finding *r* however was to omit the 2*r* term and use arc length = 20 instead of perimeter = 20. Once candidates had found a value for *r* there were many good examples of correct recall and use of the cosine rule to find *z* or sine rule with angles 40° and 70° to find *z*.