MATHEMATICS

Paper 0980/11
Paper 11 (Core)

Key messages

To succeed with this paper, candidates needed to have completed the full syllabus. Candidates should have followed the rubric on the front cover about the correct value of π to use and the number of significant figures to give in their answers. They must have used a calculator as its correct use cut down arithmetic errors. Candidates should not have rounded values between the steps of a calculation as this lost accuracy marks and candidates needed to check that their answers were in the correct form, made sense in context and were accurate. Candidates are reminded of the need to read questions carefully, focussing on instructions and other key words.

General comments

There were a considerable number of questions that were standard processes and these questions proved to be well understood with minimal confusion about what was being asked. Successfully answered questions were where candidates showed working, setting out their solutions logically, with their numbers clearly formed. Others often jotted down calculations and values in various places and without any clear order so that their methods could be hard to follow. Candidates who used arrows or lines to show connections between numbers rather than forming equations tended not to perform as well, whilst those showing no working tended to perform the least well.

Comments on specific questions

Question 1

This opening question was done well by many candidates. Occasionally, candidates gave words which describe other angles.

Question 2

Very few candidates had difficulty with this question. Most recognised that the 8 had a value of 8000 and gave a correct answer in figures or in words. A tiny minority gave an incorrect place value, usually either tens, hundreds or thousandths.

Question 3

(a) Most candidates gave the correct answer. A few did not go far enough, giving 8 − 3 as their final answer, without evaluating it to reach 5.

(b) The majority of candidates answered this correctly. Some worked out that $y = 9$ and then gave this as their final answer.

Question 4

Most candidates understood what was required here, although there were a few errors. The most common error was 229.1… which is $3\times\sqrt{5832}$, rather than using the cube root function. Some candidates confused the square root symbol for a division sign and divided 5832 by 3.

Question 5

This was a well answered question by many. However, some candidates gave the new price ($10 416) rather than the discount.

Question 6

(a) This was the first problem solving question and it was found to be challenging. However, most candidates gained some marks, with a number giving a fully correct answer. Many candidates had difficulty in meeting all of the given conditions. Candidates tended to start correctly, for example, writing 15 in the middle position, but then including further numbers that meant 15 was no longer the median, or writing 8 and 17 but then including numbers that were greater than 17. Many were able to give 5 numbers that totalled 66, with 8 and 17 as the smallest and largest. Some had a total of 66 but included repeated values meaning there was now a mode.

(b) Candidates who correctly found 5×20 and 4×17 went on to reach the correct answer. Other candidates who reached either 68 or 100 looked to be unclear how to find the second value. Others opted to use trials, first finding four specific values with a mean of 17 and then using this answer to work out the additional value.

Question 7

A good number answered this correctly. Some were awarded a single mark as they expressed their answer in an incorrect form for time, for example, 1505 pm or 15h05 mins. Common errors tended to be numerical errors, errors in conversion of minutes to hours; or through not understanding whether to add or subtract the time periods.

Question 8

It was pleasing that most candidates reached the correct answer of 98. The most common error was to assume that x was one of the two equal angles, leading to $(180 - 41) \div 2 = 69.5$.

Question 9

Many candidates used the stem-and-leaf diagram efficiently, although some candidates attempted to write out the numbers in an ordered list even though the data is already ordered in the stem-and-leaf diagram. Some candidates based their answers on the leaves and did not use the stems.

(a) There were many correct answers here. The most common incorrect answer was 7, suggesting that these candidates had forgotten to refer to the stem.

(b) A good proportion of candidates obtained the correct range. Incorrect answers included ‘’16 to 31’’ without calculation; incorrect calculations such as $31 - 17 = 14$, $30 - 16 = 14$ or $7 - 1 = 6$, giving the highest value, 31, or calculating the mode, mean or median.

(c) Many candidates gained this mark. There were a variety of errors, including, answering 5 (forgetting to refer to the stem), giving the mode or mean, answering 24.5 (or 4.5) and finding the average of the 7^{th} and 8^{th} numbers.

Question 10

There were many strong answers here. Candidates who used the diagram correctly often went on to reach the correct answer. Some were able to show one or more correct angles on the diagram and were awarded a mark, although, some candidates seemed unclear about which angles on the diagram were equal and which totalled 180°.

Question 11

This question was found to be particularly challenging. Many candidates gave the number correct to 2 decimal places rather than 2 significant figures, leading to the common wrong answer of 0.04. Some candidates incorrectly included trailing zeros, for example 0.03700.

Question 12

This question tended to be well done. The most common error was to add the cost per kilogram to the number of kilograms on the first line and then subtract when working out the cost per kilogram on the second line. Some candidates made an initial error but followed through correctly to complete the rest of the table.

Question 13

(a) Most candidates were able to identify the correct value of the car. Common errors arose from misreading the scale with answers such as 4400, 4900 and 48 000.

(b) The majority of candidates plotted this in the correct place. Inaccuracy arose from misreading the scales. A number of candidates drew horizontal and vertical lines meeting at the correct point but did not score unless a clear plot was shown.

(c) Most candidates correctly identified 'positive' for the correlation. A few attempted to describe the graph or the relationship rather than the correlation.

Question 14

This was done well, with a large number reaching the correct answer and others gaining a mark for a correct partial factorisation.

Question 15

Many candidates scored full marks, with most attempting to use prime factorisation. Some used a single table, better suited to finding the lowest common multiple rather than the HCF, and did not make it clear which numbers were prime factors of both 126 and 140, so they could not be awarded method marks. Common errors included giving the lowest common multiple (or other multiples) or slips with the arithmetic.

Question 16

(a) This was reasonably well answered. Common errors were n^5 (perhaps as candidates thought n was the same as n^0 rather than n^1) and $2n^5$ (as some thought the ns should be added rather than the indices).

(b) Most candidates were able to complete at least one step correctly, reaching a coefficient of 4 or resolving the x terms to x^4. A common incorrect response was 4^4, which scored no marks. A minority used very unclear notation, often writing the power of 4 above the x. In some cases, it was unclear whether they meant $4x^4$ or 4^4x.

Question 17

This question was found to be challenging. Some of those who used a correct method had premature rounding leading to an inaccurate final answer, or others gave the answer to only 2 significant figures. Others used an inaccurate value for π, often $\frac{22}{7}$ or 3.14. Some candidates omitted π altogether and divided 59 by 2 (or by 4), gaining 0 marks. Others started incorrectly by multiplying 59 by π as if the diameter of the circle was given in the question instead of the circumference. Some used the area of a circle formula.

Question 18

This question caused difficulty for many candidates. Either candidates did not read the question carefully enough or they were unsure how to express numbers to one significant figure. Many opted to round the figures to the nearest integer or to one decimal place. Other candidates put the numbers in their calculators as written in the question, then rounded the displayed value to 1sf. Candidates should be aware if the question states, 'You must show all your working' then marks are given for the method and zero for just an answer.

Question 19

There were some very good responses to this question. However, some candidates gained a method mark for the first step but then went no further or made errors. Candidates who started by writing $\frac{6000 \times 4 \times r}{[100]} = 840$ almost always went on to reach the correct answer. The most common error was to use the final amount, \$6840, rather than the interest only, \$840, on the right-hand side of the equation. These candidates gained a method mark for showing $\frac{6000 \times 4 \times r}{[100]}$. Some were able to reach the stage where they calculated that the overall percentage increase was 14% but forgot that this was over 4 years and omitted the final step of division by 4. Some used trials to find the correct interest rate, often successfully.

Question 20

In this question there were some pleasing fully correct responses using the correct formula for the area of a trapezium. However, some who correctly wrote the formula, made errors in its implementation. Other candidates appeared uncertain of the formula.

Question 21

As with **Question 16**, some candidates wrote the indices in the incorrect position, whilst other candidates omitted decimal points or wrote two digits in front of the decimal point.

(a) (i) There were many correct solutions to this, but common errors were to give an incorrect power of ten, often 3, or there were two digits in front of the decimal point.

(ii) It was common to see candidates not using a negative power, giving for example, 6.3×10^3, whilst others got the power wrong.

(b) Many candidates successfully reached 123 000, others arrived at 12.3×10^4, both of which scored B1. However, they then did not go on to convert this to correct standard form.

Question 22

Many candidates understood what was required here gained at least one mark. Some candidates reversed the otherwise correct values and some gave two numbers that would round to 287, such as 286.5 and 287.4, rather than the bounds of the interval.

Question 23

Most candidates were able to give the correct probability. However, some made errors when simplifying or converting to a decimal or percentage, including those who reached a correct value for a percentage, but omitted a percentage symbol. The most common error was to select the wrong values, either finding the probability of selecting a right-handed person, or totalling some of the given numbers to make the numerator or denominator in their fraction.

Question 24

(a) This question was found to be very challenging. The majority of candidates used the conversion factor for metres to millimetres, rather than for m^2 to mm^2, leading to the very common wrong answer of 1200. Candidates need to remember that converting between square units is not the same as converting between linear units.

(b) In this question the successful candidates usually approached this by converting Sophie's speed into km/h; a few converted the speed limit into m/min or converted both speeds into comparable units, usually km/min. Some converted between m and km correctly but were then unsure whether to multiply or divide by 60.

Question 25

In this question there were many good responses with clear working leading to an accurate answer. Candidates who use $\frac{22}{7}$ or 3.14 in their calculations are placing themselves at a disadvantage. Other than this, the most common error was to use an incorrect formula, usually one of the formulas for circumference, but $2\pi r^2$ and $\pi^2 r$ were also seen.

MATHEMATICS

Paper 0980/21
Paper 21 (Extended)

Key messages

Many candidates wrote partial results to only two or, at most, three significant figures and therefore their final answer was often inaccurate. In order to get an answer accurate to at least three figures, candidates need to keep more accuracy than this in their calculations and, where possible, keep the 'full' number on their calculators and use that in subsequent calculations.

General comments

Most candidates presented their work well and attempted to show full working, there were very few who only just wrote their answer down. In the geometry questions many candidates assumed properties of the shapes that were not correct. Some used classic trigonometry in triangles that did not have a right angle. In algebra many were not able to complete manipulation of equations and expressions correctly, particularly in algebraic fractions where a lot of incorrect cancelling was seen. A large number of candidates in the more challenging questions that deal with areas of sectors and triangles and trigonometry are still losing accuracy due to rounding or truncating too early as described in the key message.

Comments on specific questions

Question 1

Most candidates answered this question correctly, the common incorrect response coming from $\frac{180° - 41°}{2}$ or 69.5° and a few just gave the answer of 139°.

Question 2

(a) This was answered well, the common errors were to omit the stem and write the answer as 7 or 17 rather than 27. A few calculated the mean giving an answer of 24.3.

(b) Many candidates left their answer as 31 – 16 instead of actually subtracting it.

(c) A few miscounted and they put the middle between 24 and 25 so giving their answer as 24.5. Again a few calculated the mean as in part.

Question 3

(a) Again, this was well answered the main error was to write the answer as 8 – 3 rather than giving the answer as 5 and very occasionally $x = -5$ was seen.

(b) Sometimes the answer was given as the value of y, 9, rather than the value of $10y$, 90. Other wrong attempts seen included adding 3 to both sides to get $7y + 3 = 63 + 3$ and then $10y = 66$, or subtracting $10y$ and $7y$, and equating to 63 hence $3y = 63$ leading to $y = 21$.

Question 4

There were a great number of correct answers, some candidates made numerical errors, but we followed through any errors. Where the $7.52 was not as expected it seemed that the multiplication needed for the entry on the top line had been calculated incorrectly, sometimes it seemed to be from using $2.35 $\times$ 3.02 and on others by trying $2.35 + 3.2. The common incorrect answers were those who showed 5.55, 7.99 and 5.19. There were a few that did an incorrect mixture of subtraction and multiplication, and as little working was shown it was difficult to see what had been attempted.

Question 5

(a) This part was answered very well as most candidates gave a correct full or partial factorisation. A few candidates left the m in the second term, so they wrote $7m(6k - 5m)$.

(b) Many candidates recognised the difference of two squares. Some gave incorrect alternatives such as $(h - 12)^2$, $(h - 72)(h - 2)$ or $(h - 1)(h - 144)$.

Question 6

(a) Many gave the correct answer, a few wrote 48 000 giving an extra 0. Some misread the scale and wrote 5000, 4600 or 4000. Some drew a line of best fit and read off it by tracing $28 000 from the horizontal axis to their line.

(b) Most plotted the point accurately; some plotted it inaccurately whilst others did not plot the point at all, or they drew two lines but plotted no point.

(c) Most gave the correct answer, some others wrote the most common incorrect answer of ‘negative’ whilst others wrote ‘strong correlation’, ‘linear’, ‘direct’, ‘ascending’ and ‘proportionate’.

Question 7

Most candidates achieved the correct answer. The few candidates who made an error tended to multiply the two figures given instead of doing the correct division. As a result, the wrong answer of 99.94 Singapore dollars was seen on a few occasions.

Question 8

Some candidates did not know how to deal with fractions or mixed numbers on their calculators. Some did the correct working but did not simplify their final correct fraction to get 24 such as $\frac{2640}{110}$ or equivalent.

Question 9

There was quite a variety of answers for this question with some candidates giving the correct answer, many did not. Some candidates gained one mark for either giving the answer 2 or 7 on the answer line or showing the prime factor decomposition working or stating the prime factor product form for 126 and 140. Many candidates who attempted listing the factors could not make complete lists or they missed out some of the factors. Some candidates found the lowest common multiple of 1260 instead but if they showed the prime factor decomposition then they would gain some credit.

Question 10

(a) This was very well answered. The most common incorrect answers were n^5, $2n^5$ and $n^5 + n$.

(b) This was generally well answered with most students attempting an answer. Most candidates understood that they had to treat the numerical part of 8 ÷ 2 separately from the variable, although a common mistake was to either subtract both or divide both resulting in $4x^3$ or $6x^4$. Some candidates did part of the working but failed to complete the calculation for full marks, with an answer of 2^2x^4.

(c) This question caused more difficulty than the other parts of this question. Some candidates seemed to think that 243 was raised to the power 20 which caused many difficulties and resulted in a huge numerical answer, whilst $243 \times \frac{2}{5}$ was a common mistake giving a coefficient of 97.2.

Another common error was to leave the coefficient 243 completely untouched with a variety of powers of y. Incorrect answers often seen included $243y^8$, $97.2y^8$, y^{80} and $9y^{20.4}$.

Question 11

This was very well attempted. The most common error was to give the wrong inequality sign, or to just give 11 as the answer, even when the fully correct answer had been seen in the working. Some candidates had difficulty when their '*x*' term was negative and there was a need to reverse the inequality sign. Those who did not get the correct value for *x*, usually correctly expanded the brackets followed by errors on collecting the letters and numbers or they had arithmetic errors when adding 43 and 12.

Question 12

The correct method was written down well by many with most candidates choosing with $x = 0.4\dot{2}$ and then using either $10x - x$ or $100x - 10x$ and occasionally $1000x - 100x$. The bare working $\frac{42-4}{90}$ was seen often. A misunderstanding of the number by using 0.424242…. was also seen occasionally. A few candidates did not simplify their final answer of $\frac{38}{90}$ or $\frac{3.8}{9}$.

Question 13

Some candidates did not round their answer to the nearest whole number. A surprising number of candidates misread the 27 000 as 2700. Calculator errors were common with this question when evaluating $27\,000(0.97)^4$. This appeared to be primarily due to candidates evaluating 0.97^4 and then rounding or truncating it before multiplying by 27 000. Common errors included rounding the answer down to 23 902, using $27\,000\,(1+ \frac{3}{100})^4$ as their equation or using the same increase each year which led to 23 760.

Question 14

(a) The most common error made was to omit the 15 giving $5x + x + 5 + 12 - x = 52$ leading to $x = 7$. Another common wrong answer was 47 from candidates assuming that the intersection was 52 and $x + 5 = 52$. Other responses came up with a correct equation but then made errors in solving it giving an incorrect value of *x*. Several candidates correctly obtained $x = 4$ but either they did not realise how to use this to find the required value or substituted it into an incorrect expression.

(b) Most candidates were able to identify the central region and give the correct answer. Incorrect answers included every other combination possible, but more often the regions $(C \cap D) \cup (D \cap E)$ or $(C \cap D) \cup (C \cap E)$ or $(C \cap D) \cup (D \cap E) \cup (C \cap E)$.

Question 15

Only a few candidates answered this question completely correctly although most candidates attempted the question. Almost all candidates were able to draw the line $x = 2$ with a solid line. Most candidates were able to draw $y = 1$ but they used a solid line instead of a dashed line. Some candidates could not find the points on the line $y = x + 2$ so they drew the incorrect line. In the same way, most were able to shade $y > 1$ and $x \leqslant 2$ correctly but they struggled to give a correct shading for $y \geqslant x + 2$. Most use ruled lines although some candidates did not use a ruler, and a few did not draw any lines at all but just attempted shading up to where the line should have been.

Question 16

Many struggled with this question and especially with upper and lower bound of 9.5 ± 0.05 as they used 9.5 ± 0.5, but they usually showed 11 ± 0.5. Some others first attempted $2 \times 11 + 2 \times 9.5$ was worked out to 41 and then 0.5 added and subtracted to give 40.5 and 41.5.

Question 17

There were a number of correct approaches, some found angle *DCA* = 70° with angle *CBA* = 70°, angle *OCB* = 37° and angle *OBC* = 37° so that the required angle is 70° – 37° = 33°. Another method was angle *CAB* = 53°, angle *COB* = 106°, angle *OCB* = angle *OBC* = $\frac{180-106}{2}$ = 37° then required angle = 180° – (37° + 37° + 20° + 53°). A few used another isosceles triangle with angle *CAO* = 20°. For those who did not get the correct answer, we required either angles to be marked on the diagram or for angle identifiers to be used which was rare. Most did gain credit for correct angles identified.

Question 18

Most candidates knew how to apply the sine rule, and many fully correct solutions were seen, but unfortunately there were also quite a few who fully used the correct method, but it led to an inaccurate answer because of early truncation of figures. For those who were unaware of the need to use the sine rule, the most common mistake was to use basic trigonometry having assumed one angle to be a right angle.

Question 19

(a) There were a lot of very good cosine curves which had all the properties of the original. Some curves did not pass through (0, 1) whilst others did not pass through (90°, 0) or (270°,0). Some curves had the incorrect period whilst others did not have a minimum at (180°, –1). Some candidates did mark the points on the horizontal axis and others did not. A few curves had been drawn with a ruler which made them two straight lines.

(b) Most candidates realised that the acute angle was 77.9° or similar, though not all gave the angle to one decimal place. Only a few candidates subtracted *their* 77.9° from 360° to give the correct final answer. Many added it to or subtracted it from 180°.

Question 20

(a) Most successful attempts were made by those who factorised both fully at the same stage and then proceeded correctly to cancel common factors and then reaching the correct answer. Those who factorised only one initially were often then tempted to start cancelling incorrectly, for example $10x(x-6)$ seen and then the10 would be cancelled with 30 or x cancelled into the $-x$ or x^2. Most common errors were, factorising the denominator with signs reversed and omitting the x from the numerator on the answer line.

(b) The most successful candidates were those who combined the fractions straight away using brackets on the numerator, such as $7(8x-1)+5(x+3)$, which were then expanded and simplified to the correct numerator. Those who kept them as two separate fractions often did not get the required correct common denominator. There was no requirement to expand the denominator but some, who did, sometimes made errors. There were also some errors in expanding the numerator.

Question 21

Most candidates did not interpret the requirement to find angle *BHA* and instead attempted to find angle *BHD* or *DBH*. In most cases the truncating of the result for sides *AH*, *BD* or *BH* led to inaccurate answers. Many candidates tried to find BH using a calculation for *BD* and then they used a truncated figure to find *BH* led another inaccurate result. Those who successfully found either *AH* or *BH* then often used the incorrect trigonometry function to find the required angle.

Question 22

The usual correct method was to find the area of the triangle *ABC* and the sector area *ABC*. The area of the rhombus which is twice the area of the triangle subtract the area of the sector gave one half of the shaded area then doubled gave the required answer. Some subtracted the area of the triangle from the area of the sector which gives half of the unshaded area, doubled gives the unshaded area and subtracted from the area of the rhombus gives the required answer. Another method to find the area of the rhombus is to find the length of the diagonals using trigonometry and to multiply them and divide by two. One problem was the number of calculations and the tendency for candidates to truncate or round results to just 2 or 3 figures which led to inaccurate answers. Some candidates did not interpret the diagram correctly. They saw two isosceles triangles with the unshaded area as part of a circle, so they attempted to find the radius of this 'circle.' Many just find one or both areas of the triangle and sector and then they stopped working as they could not work out a way to find the required area.

MATHEMATICS

Paper 0980/31
Paper 31 (Core)

Key messages

To succeed in this paper candidates needed to have complete syllabus coverage, to remember necessary formulas, to show all working clearly and to use a suitable level of accuracy. Particular attention to mathematical terms and definitions help a candidate answer questions from the required perspective.

General comments

This paper gave all candidates an opportunity to demonstrate their knowledge and application of mathematics. Most candidates completed the paper, making an attempt at most questions. However, a number of candidates did not attempt all parts of the paper. The standard of presentation and amount of working shown was generally good. In a multi-step problem solving question the working needs to be clearly and comprehensively set out particularly when done in stages. Centres should encourage candidates to show formulas used, substitutions made, and calculations performed. Attention should be made to the degree of accuracy required. Candidates should avoid premature rounding as this often leads to an inaccurate answer. Candidates need to read questions again to ensure the answers they give are in the required format and answer the question set. Candidates must write digits clearly and distinctly.

Comments on specific questions

Question 1

(a) The majority of candidates were able to write the number correctly in figures. Common mistakes were, $6\frac{1}{2}$ 000 000, errors with the number of zeros, misplacing the 5 or using a 3 (half of 6) in place of the 5.

(b) This question was answered well by most candidates. Errors were, rounding to 1 or 3 significant figures (40 000 or 37 500) or incorrect rounding to 2 significant figures (37 000). Other common wrong answers were 8000, 3800 or 8508.

(c) (i) Most candidates answered all parts to **(c)** well, understanding that they needed to choose a number from the list provided. However, some candidates often gave values not in the list of numbers. Identifying a factor of 18 was the most successfully answered, with the vast majority identifying 6 or 9 or both as a factor. The most common wrong answer was 36, a multiple rather than a factor.

(ii) Many candidates were able to identify a multiple of 12 from the list, although the most common error was to give a factor of 12 (6) instead of a multiple (36).

(iii) Identifying a square number from the list was as successful as **(c)(ii)**. The most common error was choosing $\sqrt{100}$, showing understanding that 100 is a square number but not taking the root into consideration.

(iv) More candidates were able to identify the prime number in the list, 31, although common wrong answers were 9, $\sqrt{1000}$ or 28. Prime numbers not in the list were also common wrong answers.

(v) Many candidates were able to identify the irrational number ($\sqrt{1000}$). Common errors were $\sqrt{100}$ and 31.

(d) (i) Putting a pair of correct brackets in each statement was well answered by the majority of candidates. **Part (i)** was slightly more successful than **part (ii)**.

(ii) This was well answered by the majority of candidates. Common errors were to put the brackets around the 24 and 4, or not to attempt the question.

(e) Nearly all candidates were able to write the fraction as a decimal, with very few wrong answers seen.

(f) Candidates were as successful in finding the fraction of the amount, with very few wrong answers seen. Some candidates made arithmetic slips with the division part of the question, many from not using their calculator or using their calculator incorrectly.

(g) Writing down the reciprocal of a value was the most challenging part of **Question 1**, with not many candidates gave the correct answer of 2 or 2 / 1. Common wrong answers were $\frac{1}{2}$ or 5 / 10. Some candidates showed some understanding of 'reciprocal' by answering 1 / 0.5. However, this did not gain the mark as it needed simplifying.

(h) This question was well presented by the majority of candidates, with most showing the required amount of working out. However, the most common error was giving the final answer as an improper fraction rather than a mixed number as instructed. Most successful solutions involved converting to improper fractions, then to common denominators, subtracting and then converting back to a mixed number. Errors were seen in all stages, but most candidates were able to gain one mark for correct conversion of at least one fraction to an improper fraction or converting their improper fractions to common denominators.

Question 2

(a) (i) This part was well answered with most candidates correctly calculating the radius. A few candidates tried to calculate using π to find the area or circumference, or by doubling the diameter instead of halving.

(ii) Almost all candidates who attempted to draw a chord were successful. However, a significant number of candidates did not attempt this question. Tangents, secants and radii were seen. A few candidates labelled the chord and some gave a choice of answers, e.g. a radius and chord were both drawn with this only gaining the mark if the chord was clearly labelled.

(b) (i) Many candidates gained at least one mark, most commonly for the correct distance. Candidates should be reminded that they must clearly mark where C is with a line, cross or dot, not just writing the letter C. Many candidates placed C outside the question area. Candidates should be aware that the correct answer will appear in the space provided, not in the text surrounding it or with other parts of the question.

(ii) Calculating the actual distance of ship C from ship A was done well with many gaining the full marks, including from a follow through from an incorrect position of ship C in **part (i)**. A common error was to add the distances from A to B and B to C rather than measuring the direct distance from A to C.

(c) (i) Showing that the interior angle of a regular octagon was 135 degrees was done well by those that attempted it. However, a significant number of candidates did not attempt this question. Candidates showed a good knowledge of which formula to use and how to use it. Most candidates used $(8 - 2) \times 180 / 8$ rather than $180 - 360 / 8$. Some lost the mark by not showing enough working, e.g. $1080 / 8 = 135$ without $(8 - 2) \times 180$ or used 6 without showing $8 - 2$. Candidates should be reminded that in a 'show that' question they should not use the value they are trying to 'show' in their solution.

(ii) Showing that the three shapes met at a point with no gaps was the most challenging question on the whole paper. A significant proportion of candidates did not attempt this. Candidates did not understand what they were being asked to do, often putting a circle around the shared point, or redrawing the diagram with extra shapes to show tessellation. Candidates who were successful showed with a calculation that the three interior angles of the shapes added to 360 degrees.

(d) Whilst some candidates did well on this question, many candidates assumed EDF was an isosceles triangle and gave an answer of 82 from 180 – 49 – 49, or an answer of 49. Many candidates did not understand the notation and thought that 'angle EDF' meant all three angles had to be given on the answer line, or the total of all 3 angles, 180.

Question 3

(a) (i) The first three parts in **part (a)** were very well answered with most candidates gaining full marks. The most common error was reading the vertical scale incorrectly with 8.5 often seen instead of 9, in **part (i)**.

(ii) Nearly all candidates identified India as having the largest number of students.

(iii) Most candidates were able to find 7 more students lived in China than in Australia. The most common error was reading the vertical scale incorrectly with half a square as 0.5 students instead of 1 student.

(iv) Finding the percentage of students living in the USA was the most challenging part of this question. The most common error was by rounding or truncating answers without writing the unrounded answer down. Answers of 24 or 23.7 with no working gained no marks. Centres must remind candidates that exact answers must be written down, along with the working. Some candidates used a total of 100 rather than 80, so ($19 / 100 \times 80 =$) 15.2 was seen frequently. Also 79(.2) was given regularly by candidates using the total of 24, not 80.

(b) (i) This was very well answered, with most giving a correct answer of 10 (or -10). The most common errors seen was 4 from 7–3 rather than 7 – –3.

(ii) This part was again well answered, with the most common incorrect answer being 5 instead of –5. Other errors included 22 (or –22) or 9 (12 – 3).

(c) Completing the pie chart was challenging for some candidates, with many not drawing angles accurately or using a protractor. There were many completely correct pie charts seen, well drawn with a pencil and ruler. However, more commonly, candidates gained 2 marks for a correct sector (usually 54) or correct angles seen. There were sectors drawn 3 or 4 degrees out. Candidates should be reminded that the tolerance allowed on drawing angles is ± 2 degrees. A significant proportion of candidates worked out percentages rather than angles and gained no marks. Several candidates included a 'Total' as a sector and therefore had 4 (or more) sectors in their pie chart. Common wrong answers were sectors of 12, 26, 42 ,80 or 15, 32.5, 52.5, 100.

Question 4

(a) (i) Most candidates could draw all or some of the correct faces of the net, although many candidates constructed a 3-dimensional view of the cuboid. The most common mistake was to draw the height 1 cm and not 2 cm with faces 5×1 and 3×1 instead of 5×2 and 3×2. Occasionally the cuboid was drawn without a top face, drawing an open box, not a cuboid. Most nets were drawn well using pencil and ruler.

(ii) Many candidates found this part challenging. Some candidates gained one mark for the partial solution of 31, the area of 3 rather than 6 faces. However, the most common wrong answer was 30, the volume of the cuboid. Some candidates used π, despite there being no circles. Many who understood surface area struggled to use the correct dimensions and it was common to see $2 \times (5 \times 3 + 2 \times 3 + 3 \times 5)$ or $2 \times (2 \times 3) + 4 \times (5 \times 3)$.

(b) Finding the value of x, the base of the triangular prism, was challenging with all but a few candidates scoring full marks. The most common errors seen involved the calculation of the triangular prism, most treating it as a cuboid and not dividing by 2. However, most understood the concept that the cube and triangular prism had equal volume, so needed to equate the volumes of both shapes. 6 was a very common incorrect answer when a candidate calculated the volume of the cube correctly and equated it to their expression, usually 36*x*. Some candidates gave incorrect answers with no working and gained no marks. Centres must emphasise the need to show all working, in a systematic order. Some candidates attempted to use trigonometry or Pythagoras (with 4, 6 or 9) to find the length. 36, or 1296 were often incorrect volumes for the cube and 216 was sometimes seen from multiplying the 3 given numbers, $9 \times 4 \times 6 = 216$, for no marks.

Question 5

(a) The majority of candidates correctly identified the correct time that train B left Cove. Although some gave the wrong answer of 14:48, the arrival time of train B at Town.

(b) Most students were successful, finding that train A stopped at Port for 4 minutes. However, a significant number answered 5, the number of lines, or identified the time of arrival at Port 14:18.

(c) Many candidates found that train A takes 2 minutes more than train B to complete the whole journey. Most candidates did this with correct (40 – 38) or no working, but many candidates found 2 minutes using incorrect values (18 – 16) and therefore gained no marks. Common wrong answers were 8 minutes, the difference between finishing times, or 10 minutes, the difference between start times, whilst others compared only parts of the journey or gave the answer as a time of day (14:40 or 14:48) rather than a period of time.

(d) Nearly all candidates found that the two trains passed each other at 14:25. In **parts (a)** and **(d)** most candidates gave answers, as expected, in 24-hour times, matching the information in the question. However, several candidates chose to change to 12-hour times, which scored full marks if given with pm, however some gave answers of 2:10 and 2:25 in **parts (a)** and **(b)** and therefore scored no marks. If candidates choose to change time formats, they must be correct.

(e) Calculating the average speed of train A proved to be challenging for many candidates. Many did not use the correct formula, whereas others had difficulty finding the appropriate time in hours (2 / 3 hour) but often gained 1 mark for dividing by an appropriate time, although in the wrong units (40 minutes). A very common error was rounding the time prematurely (0.67, 0.66, 0.7 hours) and therefore lost accuracy when dividing. Candidates should be reminded not to round fractions to decimals but to use the time in fractions rather than decimals. Some candidates often divided by the time of day (14:40) rather than the time taken. Most candidates correctly found the distance travelled to be 23 km, although, some used 24 km instead.

Question 6

(a) This part was answered reasonably well with most candidates able to identify the given transformation as a translation, although common wrong answers were 'translocation'. 'movement', 'shifted'. However, only some candidates were able to give the vector, either as a column vector or in words. Most errors were in an incorrect format, often given as a coordinate, or the numbers were in an incorrect order, or there were incorrect negative signs. A number of candidates described a double transformation (translation and rotation) or used non-mathematical descriptions.

(b) More candidates were able to identify the given transformation as an enlargement although few were able to correctly state all three required components. The centre of enlargement proved the most challenging with a significant number omitting this part. The answer of 1 / 3 for the scale factor was the most common error. A significant number gave a double transformation (enlargement and translation), which gained no marks.

(c) Fewer than half the candidates were successful in drawing the image of triangle A after a reflection in the line $y = 6$. A significant number of candidates did not attempt the question or did not draw the triangle even after correctly drawing the line $y = 6$. Most candidates drew the image after a reflection in the y axis or attempted to reflect in the line $y = 6$ but ended up translating the triangle rather than reflecting it.

Question 7

(a) This simplification question was well answered by the majority of candidates. Common errors seen were 7a + b, 7a – 7b or 7a + –b, these all gained one mark for a partial solution. Candidates should be reminded that leaving a double sign (+–) in their expression will not gain full marks. Some candidates had squared terms or an ab term in their answers. 1b was condoned for b.

(b) Finding the value of x was equally well answered by most candidates. Most candidates gained at least one mark for a correct substitution of 21 and –5. However, some candidates added rather than multiplied 3 by –5. Sign errors were seen when rearranging to find x. The most common wrong answer was –4.5 from $8x = -36$. Many candidates gained the method mark but then made errors in solving the equation. A few candidates did 21 – 5 = 16 from the numbers in the question, only substituted the P = 21 then rearranged to (x =) (21 – 3y) / 8 or substituted x = 21 then calculated P (= 153).

(c) Candidates found making v the subject of the formula the most challenging part of this question. The most common error was to square root first. A common misunderstanding was that kv^2 meant that the k and the v were both squared, so square rooting gave $\sqrt{S} = kv$ and subsequently $v = \frac{(\sqrt{S})}{k}$. Another error was to divide by kv or to subtract k rather than divide by it. The square root sign had to cover the whole of S / k to gain full marks, with 'short' square root signs seen and not gaining full marks, despite correct steps shown in the working. The notation : or ÷ for division was accepted. Some candidates made a correct first step and reached $v^2 = S / k$ but then did not know how to deal with the square.

(d) Many candidates were able to expand and simplify the double bracket successfully, with most candidates gaining at least 1 mark for a partially correct expansion or correct expansion and an incorrect simplification. Common errors were with signs ($5x - 3x$ or 15 instead of –15) or simplifying ($-3x + 5x = -2x$). $x^2 - 15$ was commonly seen from some candidates by doing First and Last only, rather than the complete FOIL method.

(e) This forming and solving equations question was challenging for most candidates with many varied responses seen. Most candidates who found the value of x to be 18 did so by forming a correct equation, from the information given and then solving. However, candidates could gain full marks by using a trial and improvement method. Most candidates were able to gain the first mark, but many were unable to gain the next mark as their equation did not involve three terms in x. Once candidates had formed an equation in the required form $ax + b = c$ they were then successful at solving for x and gaining follow through marks. The most frequent wrong answer was $x = 35$ from $3(x + 15) = 150$. Other common errors were; $15x$ for Selina; $x + 15 \times 3$ for Hanif and then simplify this to $x + 45$; equate the expressions for only 1 or 2 people to 150; combining x-terms to get powers of x. Few candidates checked their answer for x with the original information to see if they were correct.

Question 8

(a) Many candidates did not answer in the correct format ($mx + c$) and therefore gained no marks. Those that did use this format produced a variety of answers with only some gaining both marks. Several lost a mark by giving the solution $2x + -5$, without simplifying to $2x - 5$. Common errors were entering coordinates wrongly into the correct formula for gradient, or making errors with subtracting negative numbers, gradients of $\pm 1 / 2$ from difference in x / difference in y.

(b) (i) Drawing the line $y = x$ was one of the most challenging questions. This could have been because there was no table of values to complete and very few candidates chose to draw their own. Most lines drawn were either horizontal or vertical lines, most commonly the axes, or having a negative gradient. It was difficult to see many candidates attempts as they often drew over top of the axes. Candidates should be reminded to use a ruler and pencil and make their answers clearly stand out, possibly through labelling their line.

(ii) Although few candidates drew the correct line in the previous part, a larger number of candidates were able to gain a follow through mark by identifying the point where their line crossed $y = 2x – 5$. A common error was to identify the coordinates where $y = 2x – 5$ crossed the axes and merge them as (2.5, –5).

(c) (i) Nearly all candidates were able to gain full marks by completing the table correctly. The few errors seen involved missing minus signs or an attempt to make a straight line with the points already given.

(ii) Most candidates gained full or part marks as they were able to plot the points correctly with occasional slips in accuracy, particularly on the non-integer coordinates. The curves were not as well drawn with many incorrectly passing through or running along $x = –1$ or $x = 1$ for more than 5 small squares, joining points with straight lines or joining the two separate sets of points.

Question 9

(a) Most candidates found this problem-solving question very challenging. However, many candidates did gain part marks by multiplying some of the correct numbers together. A small number of candidates omitted to identify which value was higher or did so incorrectly. Most candidates made more than one attempt at this question, often using the $204 in a second calculation and then comparing the wrong values.

(b) The vast majority of candidates gained full marks. However, common errors included dividing by 21 instead of 36, or incorrectly working in percentages,

(c) (i) Most candidates placed the values 18 and 11 in the correct regions and therefore gained one mark. However, only some candidates were able to correctly complete the Venn diagram. Most candidates gave the ‘only gold’ value as 46 and therefore calculated ‘only silver’ as 35. A small number of candidates used tallies or dots instead of numbers which gained no marks.

(ii) Many candidates did well on this question. Although, some gave the total for G (46 or 64) and a smaller number gave other values from the diagram or variations of incorrect set notation. A common wrong answer was 1. This showed a misunderstanding of the Venn diagram and notation as they had counted how many numbers in the intersection rather than the number of people in the intersection.

(iii) Most candidates scored full marks from a correct follow through answer from their incorrect Venn diagram. A few candidates attempted to give their answer as a percentage, with some losing the mark due to insufficient accuracy, giving to 2 sf instead of 3 sf, or missing the % sign. Common wrong answers were: an answer of 1 / 46 or 1 / 110; placing the correct value over 99 or 100 instead of 110, or using an incorrect numerator by choosing the wrong value or sum of values from their diagram.

(d) Many candidates were able to identify the correct region and use the correct notation. However, a variety of errors were seen including ‘intersection’ of sets (E ∩ F), addition of a complement symbol (E U F)'; use of a preceding ‘n’, n(E U F) ; or using the letters from the previous Venn diagram (G U S).

Question 10

(a) Candidates who were able to calculate the correct scale factor usually went on to gain full marks. Many candidates added or subtracted numbers, 17.6 from 12.8 + 14.4 – 9.6, or matched the wrong sides as similar, 28.5 from 21.4 × 12.8 / 9.6. Many candidates had the right idea but used the ratio the wrong way up, so 9.6 / 14.4 × 12.8 = 8.5. Some candidates tried to involve 180° or Pythagoras or trigonometry unsuccessfully. The side UV (= 21.4 cm) was used by some candidates even though it was not relevant to the solution.

(b) Not all candidates recognised that Pythagoras was required to calculate BC. Successful solutions subtracted the squares and went on to score full marks. Some candidates incorrectly added the squares. Long methods using trigonometry were seen but were usually unsuccessful.

(c) Many candidates realised that trigonometry and cos 35 was required and achieved full marks, with full working shown. However, some completely correct methods did not gain full marks due to rounding the answer to 6.9, or 6.8 which lost the accuracy mark, unless they showed 6.88 or better in the working. Many candidates attempted a long method using sin to find DE and then Pythagoras to find EF. Again, this was often spoilt by premature rounding. The sine rule was seen often with 90 degrees, rather than the usual sine ratio. Common errors included using sin instead of cos, or 35 without cos, or inverted the cos ratio. Confusing the angle and side in a trignometric ratio was often seen, for example, 35cos(8.4).

(d) Only some candidates were able to show a correct method to find the angle JKL. Many calculated side KL, the hypotenuse, using Pythagoras, and gave that as their answer for the angle. Some of those who used tan often gave the fraction as 8 / 10 instead of 10 / 8, thereby finding the wrong angle.

MATHEMATICS

Paper 0980/41
Paper 4 (Extended)

Key messages

To achieve well in this paper, candidates need to be familiar with all aspects of the extended syllabus. The recall and application of formulae and mathematical facts and the ability to apply them in both familiar and unfamiliar contexts is required as well as the ability to interpret situations mathematically and problem solve with unstructured questions. Work should be clearly and concisely expressed with answers written to at least three significant figures unless instructed otherwise. Exact answers should not normally be rounded. Candidates should show full working writing values with at least 3 significant figures throughout, while storing more accurate values in their calculators, to ensure that method marks are considered where answers are incorrect. Candidates should not approximate within the working of a question. Candidates should not erase or cross out working if it is not going to be replaced. In 'show that' questions candidates need to ensure that no steps are missing and should not take short cuts to answers or just aim to achieve the exact answer as given in the question. If a numerical value is given, then they must evaluate their answer to a greater degree of accuracy than the given value. It is important that candidates take sufficient care with the writing of their digits and mathematical symbols. Candidates using π as $\frac{22}{7}$ or 3.14 are likely to achieve answers out of range. When solving quadratic equations candidates should show their working. If the quadratic formula is used then they must show the values of *a*, *b* and *c* substituted into the formula. The calculator function for solving quadratic equations should not be used in these circumstances. In all questions candidates should show methods using correct mathematical operators and not, for example, crossed arrows instead of multiplication in conversion of units questions.

General comments

Candidates scored across the full mark range however many candidates found the application of mathematical skills to less familiar contexts a challenge. Candidates appeared to have sufficient time and only a small minority of candidates were clearly not ready for the demands of the extended paper.

Solutions were usually well-structured with clear methods shown in the space provided on the question paper but too many marks are lost by candidates rounding values too early when they note them down in the working of a multistep solution. An increasing proportion of candidates are leaving answers in the fractional or surd form as given on their calculators. If the question is in context candidates need to give numerical answers to an appropriate degree of accuracy.

The first three questions contained some straightforward parts and almost all candidates were able to accumulate a good number of marks at this stage. In Statistics, estimation of the mean from a grouped frequency table and drawing a histogram was accessible to most but Probability was more challenging. In Mensuration many candidates did not understand the physical process of forming a cone from a sector of a circle. In Geometry many candidates did not make use of the volume scale factor for similar solids, instead attempting to find new component volumes with the new length measurements. In Vectors many did not understand the importance of direction, both in using and interpreting vector notation and in following vector journeys. The concept of equating coefficients of vectors was also challenging. Some candidates lack precision and correct language when describing transformations. In Algebra, differentiation of ax^n to nax^{n-1} was done well and many candidates understood that at stationary points the gradient is 0, however most candidates were not able to determine the nature of stationary points with enough rigour. Many aspects of functions were well executed but the distinction between $g(x^2)$ and $(g(x))^2$ was not well applied.

Comments on specific questions

Question 1

(a) (i) Many candidates correctly identified the single transformation as a translation. Correct vocabulary is expected so for example translocation, transportation or move are not acceptable. The correct column vector $\begin{pmatrix}-7\\-1\end{pmatrix}$ was identified by many but there were also instances of incorrect signs and/or the components reversed. The co-ordinates $(-7,-1)$ are not accepted. The errors $\begin{pmatrix}-6\\-1\end{pmatrix}$ and $\begin{pmatrix}-8\\-1\end{pmatrix}$ were also seen.

(ii) Most candidates correctly identified the rotation of 90° although a significant number incorrectly stated the direction as anticlockwise. Although many candidates correctly found the centre of rotation at (5, 1) many others omitted the centre completely or gave an incorrect point. The vector $\begin{pmatrix}5\\1\end{pmatrix}$ is not accepted for (5, 1)**.** Candidates who state or imply more than a single transformation cannot score. For example, 'rotation 90 clockwise and move $\begin{pmatrix}-1\\5\end{pmatrix}$' scores 0.

(b) (i) This reflection in the line $y = 2$ was done well. Occasionally reflection in $y = k$, $k \neq 2$ or in the line $x = 2$ was seen. Some candidates reflected triangle C instead of triangle A.

(ii) Candidates found this negative enlargement a challenge. Some candidates omitted it completely while others produced an enlargement of scale factor 0.5 or 2. Some candidates completed a correct transformation of two vertices using two guidelines from the object through the centre, but then misplaced the third vertex to get an image of the correct size but incorrect orientation.

Question 2

(a) Almost all candidates evaluated s correctly. A very occasional error seen was $\frac{1}{2}(9.8\times20)^2$.

(b) Most candidates expanded $5(4y - 3) = 15$ and solved this equation correctly. Several candidates reached $20y - 15 = 15$ but then made a sign error to reach $20y = 0$.

(c) Many candidates correctly expanded and simplified $3(5x-8)-2(3x-7)$ to reach $9x-10$. The most common error was the sign error $15x-24-6x-14$ to reach $9x-38$ and some other candidates after expanding the brackets, equated to 0 and solved their equation.

(d) There were a lot of very good responses to this question. Most candidates understood the order of operations and the steps required to rearrange the equation. Many candidates took the recommended approach of writing a line of working for each step in re-arranging to make c the subject of $A = 2b^2 - 3c^3$. This ensured that marks could still be awarded for relevant work after a sign error had been made. The error $A - 2b^2 = 3c^3$ was common, or after the correct $A-2b^2 = -3c^3$,the incorrect $\frac{A-2b^2}{3} = c^3$. Other errors included square rooting instead of cube rooting for the final step. It is possible that this was caused by lack of attention to the notation for cube root as some other candidates were seen to switch from the correct notation of $\sqrt[3]{\ }$ to the incorrect $\sqrt{\ }$ for their final answer. Another common issue with notation concerned a lack of appreciation of the difference in meaning between the expressions $\frac{\sqrt[3]{2b^2-A}}{3}$ and $\sqrt[3]{\frac{2b^2-A}{3}}$. When writing such expressions, it is essential that the cube root clearly extends below the fraction line to avoid any ambiguity. The most common error in the process for re-arranging was to make $3c^3$ the subject but then to cube root before dividing by 3.

(e) This question had a mixed response. Many candidates successfully factorised $6pq-4q-3p+2$ to $(3p-2)(2q-1)$ or equivalent but many others did not know what to do with this sort of expression. When first factorising, many candidates did not realise they needed to have the same expression within the two brackets if they were to factorise further. This was generally due to not being able to deal with a negative common factor. So, for example $2q(3p-2)+1(-3p+2)\,or\,3p(2q-1)+2(1-2q)$ were often seen which could not then be progressed correctly.

Question 3

A number of candidates misread the data in the table by not looking closely at the headings.

(a) (i) Almost always correctly answered.

(ii) This was also well answered. The five-figure answer was exact, and many candidates gave this answer. Other candidates rounded to three significant figures. This was not penalised, but candidates should be aware that an exact answer should not normally be rounded.

(iii) This was generally well answered although a significant number of candidates lost this mark by giving their answer to one or two significant figures.

(iv) This was also generally well answered. The answer when rounded to three significant figures was 3000 and so many candidates understandably gave more accurate answers which were accepted. The most frequent error was to find the Earth's distance as a percentage of Neptune's distance. This was probably because candidates did not expect to be calculating the larger quantity as a percentage of the smaller quantity.

(v) The introduction of astronomical units (AU) was implemented well by many, but some candidates used diameters of planets instead of distances from the Sun. The direct method was to multiply the 5.20 AU by the distance from the Sun of Mars divided by the distance from the Sun of Jupiter and this method was seen from the stronger candidates. The other efficient method was to find the number of kilometres equivalent to 1 AU and divide the distance of Mars from the Sun by this value. A small number of candidates had fully correct working but gave their answer to only two significant figures.

(vi) This reverse percentage question was found to be quite challenging, possibly because of the context of the question. A significant number of candidates used the distance of Mars from the Sun instead of the diameter. Many candidates treated the diameter of Mars as 100% and calculated 1.392×6800 or 0.608×6800.

(b) (i) This was a 'show that' question and candidates are expected to show all the steps in a calculation. The conversion of years into seconds was frequently either simply stated as 31 557 600 or with the product $365.25 \times 24 \times 60 \times 60$ only partially shown. 3600 was accepted for 60×60 but $86\,400 \times 365.25$ was often seen and was not sufficient. The other common error was to omit a value to more than four significant figures to show that it rounded to the value given in the question.

(ii) This part proved to be challenging with many candidates dividing the given distance in kilometres by the speed of light, which was given in kilometres per second, thus giving their answer in seconds. Some of the stronger candidates realised that this answer was in seconds and divided by 31 557 600 to convert into years, possibly recognising that this is what they did in part **(i)** Candidates should be encouraged to look at a link between parts when the earlier part was a 'show that' question. The stronger candidates did realise this connection and simply divided the distance of the Andromeda Galaxy to Earth by the given value in part **(i)**.
As in part **(a)(v)** some candidates gave their answer to only two significant figures.

Question 4

Candidates should be aware that any probability greater than 1 cannot be correct and should prompt a second look at the method they have used.

(a) (i) Many tree diagrams were correctly completed, however, in some, whilst 2/5 was given as the probability for the first branch, on the second branches the 5/9 and 4/9 were the wrong way around, either for one pair or for both pairs. In other cases, incorrect probabilities were given for the second branches and these probabilities often did not add up to 1 for each pair of branches. Occasionally, candidates did not have 2/5 as their probability of spinner *A* landing on a number that is not prime.

(ii)(a) The correct method $\frac{3}{5}\times\frac{5}{9}$ was usually used by candidates to find the required probability. In a few cases, the correct probability was doubled in error, or probabilities were added rather than multiplied. The incorrect answer of $\frac{8}{14}$ from $\frac{3}{5}+\frac{5}{9}$ was relatively frequent.

(ii)(b) Many candidates interpreted this question as 'the probability that the two numbers are <u>both not</u> prime' instead of the required 'the probability that the two numbers are <u>not both</u> prime' and so $\frac{2}{5}\times\frac{4}{9}=\frac{8}{45}$ was a very common incorrect answer. Some candidates did however correctly follow through their answer in **part(ii)(a)** using the efficient method of subtracting this from 1.

(b) Most candidates obtained the correct answer in this part. Common incorrect answers included $\frac{72}{120}$, $\frac{2}{5}\times 120=48$, and $\frac{120}{3}$.

(c) Candidates found this question part challenging. A common error was to only consider some, not all, of the relevant possibilities so partially correct methods, such as $\frac{4}{9}\times\frac{2}{9}\times 2$ or $\frac{4}{9}\times\frac{2}{9}$, or $\frac{4}{9}\times\frac{2}{9}+\frac{2}{9}\times\frac{2}{9}$ were seen. Other candidates included too many combinations in their methods, giving rise to, for example, $2\left(\frac{4}{9}\times\frac{2}{9}+\frac{2}{9}\times\frac{2}{9}\right)$ or $4(\frac{4}{9}\times\frac{2}{9})$. Where candidates attempted to list the possible outcomes, there were invariably many omissions and possibility diagrams were not always drawn correctly, with values missing or the relevant possibilities not highlighted. A significant number of candidates omitted this question part or attempted to use 'non replacement' probability methods.

(d) This was found to be one of the most challenging question parts on the paper**.** Many candidates omitted the question part completely or gave common incorrect answers using $\frac{4}{9}n$ or $\left(\frac{4}{9}\right)^n$. Some attempts, though incorrect, demonstrated some understanding of what was required with answers such as $\left(\frac{5}{9}\right)^n\times\frac{4}{9}$ or $\left(\frac{4}{9}\right)^n\times\frac{5}{9}$

Question 5

(a) Many candidates were able to answer this question successfully with careful and well thought out strategies set out in clear steps. A small number of candidates clearly understood the strategy and steps required but lost the final mark because of premature rounding.

For those candidates who did not get maximum marks, the vast majority were able to use right - angled trigonometry or the sine rule with angle 38 and 52 or 90 to find the length *BD* or *AB*. Incorrect attempts to find *CD* or angle *ACD* then often followed by incorrectly treating triangle *BCD* as right-angled. Some candidates began incorrectly by assuming *AB* was equal to *BC*.

(b) Many candidates were able to locate the midpoint of FG as the centre of the circle. Common errors included placing a cross at the centre of the triangle or on one of the vertices. Many candidates tried to draw the circle using compass constructions even though this was not required.

Very few candidates were able to use 'angle in a semi-circle is 90°' or similar as the correct reason for the placement of the cross. Many of the incorrect explanations were focused on compass constructions rather than a circle theorem.

(c) Most candidates were successful in gaining some marks for this question part. In triangle *LMN* many candidates correctly used the ratio of angles and the sum of angles equal to 180 to find the largest angle 72. The error of using the sum as 360 was seen and other candidates found the angles of triangle *PQR* first and then tried to apply the ratios to these angles to find those in triangle *LMN*, for example $\frac{6}{15} \times 82.8$. In triangle *PQR* many candidates understood that the cosine rule was needed and of these many were able to recall this correctly. Candidates should be aware that no marks can be gained for quoting the cosine rule until relevant values have been substituted in. Candidates who do not show the substitution and then give an inaccurate value for the cosine or the angle, will not score. Some candidates did not appreciate that the largest angle is opposite the longest side and so often all three angles were calculated. Alternatively, the cosine rule was used to find angle *P* and/or angle *Q* and then the sine rule or angle sum of a triangle to find angle *R*. Inefficient methods usually lost accuracy. A minority of candidates tried to use right angled trigonometry for this question despite both triangles being non-right angled.

Question 6

(a) Sequence *A*: Most candidates were clearly familiar with tackling problems with linear sequences and were able to state the next term as 9. The common difference of 4 together with trial and error or using $a + (n - 1)d$ usually resulted in the correct n^{th} term, $4n - 11$. Weaker candidates often tried to use term to term rules and a common wrong answer was n+4.

Sequence *B*: Using 1st and 2nd differences candidates were able to deduce the next term correctly, but deriving the formula for the nth term was more of a challenge. Many candidates correctly showed second differences of 4 and deduced that the sequence was quadratic but not all were then able to reach the correct n^{th} term $2n^2 + 5$. The most successful candidates were ones that understood that a second difference of 4 indicates the coefficient of n^2 is 2.

Sequence *C*: This proved to be challenging for many students. Some saw the patterns that the numerators were increasing by 1 each time and the denominators were each three times greater and so were successful in finding the next term. An attempt could then also be made at finding the n^{th} term using powers of 3 in the denominator. Candidates should be very careful when writing powers so that for example $3n$ and 3^n are clearly distinguishable. Candidates who used ar^{n-1} for a geometric progression usually achieved the correct denominator $27 \times 3^{n-1}$ but other candidates made errors in manipulating numbers in index form such as $9 \times 3^n = 27^n$. Some candidates appeared not to consider a power sequence at all and instead attempted to find a cubic sequence.

(b) This part was done well. Many candidates understood the information given and processed it well.

Question 7

(a) Finding an estimate for the mean from a grouped frequency table is a familiar question and many fully correct answers were seen. It is recommended that candidates show the working $\frac{217.5 \times 9 + 221.5 \times 14 + 229 \times 14 + 239 \times 2 + 254 \times 3}{42}$ so that minor errors in mid-values or slips when entering data to the calculator do not prevent method marks from being awarded. A slightly incorrect total for $\sum fm$ with no previous working shown will score 0. Errors seen included using the upper or lower bounds instead of mid values, using group widths instead of mid-values, and occasionally adding mid-values or frequencies and dividing by 42 or 5. Some of these methods gave a value for the average that was outside the range of the data instead of somewhere in the centre of the data but this appeared not to have been considered.

(b) Many fully correct histograms were accurately drawn. Some candidates showed correct calculations for frequency density but misinterpreted the vertical scale for one or more blocks. Other candidates drew blocks at the correct heights but ended the first block at time 225 or started their third block at 235. Other candidates looked for other connections between the heights of the blocks and the frequencies. Using the first given block they deduced that frequencies should be divided by three and extended the grid to draw blocks at height above 4 or used the last given block to divide the frequency for group $234 < t \leqslant 244$ by 20.

Question 8

(a) (i) In this 'show that' question candidates were expected to show every step in their working before evaluating their final volume to at least 4 significant figures to show that when rounded to 3 significant figures the volume of the solid would be 692. Many correct formulae for the volume of a hemisphere and the volume of a cylinder, with correct values substituted, were seen but candidates who did not then show the addition of the three volumes and went directly to the given value of 692 lost both a method mark and the accuracy mark. Candidates who wrote down values rounded to only 2 or 3 significant figures for each volume in their working or used 3.14 or 22/7 for π usually lost the accuracy mark. Some candidates omitted the division by 2 for a hemisphere as opposed to a sphere. Recall of the formula for the volume of a cylinder was mostly good but the errors $2\pi rh$, $2\pi r^2$ and $2\pi rh + \pi r^2 h$ were seen.

(ii) A large proportion of candidates did not understand the significance of the first line of the question which stated that the solids were mathematically similar. Many candidates just used the new radius on the cylinder and kept all the other dimensions the same. For those that did understand that all the dimensions had changed, most approached the problem by trying to calculate the new volume with the new dimensions. Very few used the length/volume scale factor relationship which was the intended method and the most efficient. Recalculating all the volumes inevitably led to issues with accuracy. Most candidates realised that they needed to multiply their new volume by 10.49 to find the mass and gained the SC mark.

(b) (i) Many candidates showed a correct method in this question part but of these, a significant number did not give their answer as a multiple of π and so did not score full marks. Other common errors included using the formula for area instead of circumference or finding the minor arc using angle 144 even though this was not shown on the diagram provided.

(ii) This question part was very demanding for many candidates. Candidates appeared unable to visualise how the 2D shape could be manipulated into a cone. Candidates who drew a sketch of the cone were usually more successful in finding an approach to solving the problem. Their first step needed to equate the length of the arc from **part (b)(i)** to $2\pi r$, to find the radius of the cone. This could then be used in Pythagoras' theorem together with the slant height of 10 to find the height, but common errors included attempts to use the angle 216 or 144 in some way to find either the radius or the height. Candidates who successfully found the radius and the height usually went on to complete the substitution in the given formula correctly to find the volume. The most common error was to simply substitute 10 as the height and/or radius into the given formula.

Question 9

(a) (i) Most candidates responded to this question and answered it correctly. Common incorrect answers were '+ 20' after processing multiplication of positive and negative numbers incorrectly, and '2' from correctly substituting the value x=0 into all 3 brackets but then adding rather than multiplying (i.e., '1 + 5 – 4')

(ii) The vast majority of candidates responded to this question and answered it correctly. Common errors arose from processing the '-3' in $g(x) = 2x - 3$ incorrectly, leading to the answer $y = \dfrac{x-3}{2}$
Many candidates began by stating $x = 2y - 3$ correctly but then continued with $x - 3 = 2y$. A few candidates began with $y = 2x - 3$ and correctly rearranged into $x = \dfrac{y+3}{2}$ but then did not state the inverse of *g* in terms of *x*.

(iii) Many candidates understood the composite function notation and began by finding $h(2) = 64$ and then finding $g(64)$. The most common incorrect answer seen was '64' arising from substituting $x = 2$ into both functions g and h separately and then multiplying the answers.

(b) Many candidates responded to this question and answered it correctly. A common error amongst candidates who responded incorrectly was to form the equation $2(2x – 3) = 7$, leading to $4x – 6 = 7$ and an answer $x = 3.25$, instead of forming $2(2x) – 3 = 7$, leading to $4x – 3 = 7$ and the correct answer of $x = 2.5$.

(c) Many candidates found this part more challenging. Some misinterpreted the meaning of $g(x^2)$ and proceeded to expand $(2x – 3)(2x – 3)$, instead of beginning their working with $2x^2 – 3$. If candidates processed $g(x^2)$ correctly, the most common error was incorrectly dealing with the *gg(x)* term. A final answer of $2x^2 + 4x - 8$ arose from misinterpreting *gg(x)* to be $2(2x – 3)$ instead of $2(2x – 3) – 3$.

(d) Candidates found this the most challenging part of this question. It was rare to see correct answers. Common errors included substituting $x = 16$ into *h(x)* and giving the answer 4^{31} or $4.6116\ldots \times 10^{18}$. Other candidates completely misunderstood the h^{-1} notation and interpreted this as a reciprocal, giving the answer $\frac{1}{4^{31}}$ or 4^{-31}. Others attempted to deal with the inverse function and ended up calculating the 31st root of 4 (= 1.045…). Some candidates began correctly with $4^{2x-1} = 16$ but did not know how to progress from here. Most candidates that reached $4^{2x-1} = 4^2$ continued to a correct answer.

(e) Of those candidates who attempted this part, the ones who were most successful were those who set out their working clearly and began by expanding one pair of brackets then, after simplifying, set out clearly the multiplication of this quadratic and the third bracket to form the cubic expression. Inconsistent use of brackets, e.g., not surrounding their answer to the expansion of the first two brackets, led to errors when multiplying their answer by the 3rd bracket. A small number of candidates expanded the 1st and 2nd brackets and then the 2nd and 3rd brackets to arrive at two quadratics that they either attempted to multiply or simply add. Some candidates stated the correct cubic but, in the answer spaces for *a*, *b*, *c* and *d*, did not transfer their answers correctly, often omitting the negative signs for *c* and *d*.

Question 10

(a) The absence of a given diagram created a challenge for many candidates. There was plenty of space on the page for candidates to draw their own diagram to help in this part.

(a) (i) The direction of the given vector, $\overrightarrow{CA}$, created the need to adapt and look at the direction from *A* to *C*. Many candidates did not realise this and the answers (–7, 22) and (–15, –6) were frequently seen instead of (15, 6).

(ii) Again, direction proved to be a challenge with the absence of a diagram. Many candidates gave the vector $\overrightarrow{AB}$ $\begin{pmatrix} -3 \\ -24 \end{pmatrix}$, or $\begin{pmatrix} 5 \\ 4 \end{pmatrix}$ from adding the coordinates of *A* and *B*, instead of the vector $\overrightarrow{BA}$.

(iii) The calculation of the modulus of a given vector was more successful with most candidates knowing this was a Pythagoras calculation. Some candidates had -11^2 instead of $(-11)^2$ and some candidates did not recognise the modulus notation and gave a column vector as their answer.

(b) (i) Vector geometry is always a challenging part of the syllabus. Many candidates were able to gain some credit for stating a correct route for $\overrightarrow{OR}$ such as $\overrightarrow{OM} + \overrightarrow{MR}$. As in part **(a)**, direction was occasionally a problem with for example $\overrightarrow{MN}$ = **a** – **b** instead of **b** – **a** sometimes seen. Most candidates dealt with the ratio correctly with the fractions $\frac{2}{5}$ or $\frac{3}{5}$ usually seen correctly with $\overrightarrow{NM}$ or $\overrightarrow{MN}$.

(ii) This was one of the most challenging questions in the whole paper.

(a) This part proved to be very challenging and discriminating. Equating two expressions for $\overrightarrow{OT}$ was rarely seen. Another difficulty was notation and it appeared that *c* was being treated as a vector. The stronger candidates did obtain the two expressions for $\overrightarrow{OT}$ and most went on to equate the coefficients of **a** and **b**.

(b) This part was well answered by the few candidates who had succeeded in part **(a)** and also by a few candidates who used –**a** + **b** + the given $\overrightarrow{NT}$ and correctly followed through with their value of *k* in part **(a)**.

Question 11

(a) Most candidates differentiated the cubic correctly. The most common wrong answers were, $3x^2 - 8x$ and $3x^2 - 8x - 3x$.

(b) Candidates followed through their answer to **part (a)** and began the process of finding the two stationary points by equating to 0. Many used the quadratic formula correctly and some were able to factorise. The question demanded that candidates showed all their working so candidates were required to show how the quadratic equation was solved. Stating the solutions alone did not earn method marks. If using the quadratic formula candidates must show relevant values for *a*, *b* and *c* substituted in, and care must be taken to process $(-8)^2$ and not -8^2. Once solved most candidates knew that they needed to find the corresponding values of y. (3, –18) was often found correctly but errors in the substitution process made (–1/3, 14/27) a less frequent answer. Some candidates lost the accuracy mark due to stating the co-ordinates to only 2 significant figures.

(c) It was rare to see completely correct responses in this part although many candidates seemed to understand a method for deciding if the points were maximum or minimum. The most frequently seen method was to substitute their x values into the second derivative. After evaluating these expressions most candidates jumped to their conclusions without a rigorous explanation. For full marks it is necessary to state <0 or >0 for each derivative and then to write the co-ordinates of each stationary point with the conclusion maximum or minimum. The alternative efficient method to gain all marks is to draw a reasonable sketch of a positive cubic and write the co-ordinates of the stationary points in full with the conclusion of maximum or minimum, but this was not seen very often.