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Examiners' Report
Principal Examiner Feedback

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Students who were well prepared for this paper were able to make a good attempt at all questions.

Students were less successful in applying summation of a series to a problem and differentiation in a kinematics problem.

On the whole, working was shown and easy to follow. There were some instances where students failed to read the question properly, for example, in question 5 some students did not realise $2x$ represented the height of the cylinder.

Finding the compound interest, surds, algebraic manipulation and bounds seemed to be a weakness for many students. Operations involving negative numbers also caused difficulty.

Generally, problem solving and questions assessing mathematical reasoning were tackled well.

Question 1

Students found this to be a good opening question with most students able to access the first mark by converting the two mixed numbers to improper fractions. Students had two options to show the answer, the first option was to multiply the numerators and the denominators to obtain $\frac{176}{30}$ then cancelling down to $\frac{88}{15}$ and showing that this is equivalent to $5\frac{13}{15}$. The second option was to cancel the improper fractions first to obtain $\frac{8}{5}\times\frac{11}{3} = \frac{88}{15}$ and then showing that this is equivalent to $5\frac{13}{15}$. Students need to be aware that where they are being asked to 'show that' something is true then every small step needs to be shown, particularly when a calculator can be used. Sadly, many students missed out a vital step, such as reaching $\frac{176}{30}$ but then going from this directly to the given $5\frac{13}{15}$, missing out the intermediate step of $\frac{88}{15}$ or $5\frac{26}{30}$ thereby losing the final mark. It should be noted that those students who were able to cancel first to get $\frac{8}{5}\times\frac{11}{3}$ invariably gained the final mark. Some students took a third approach by writing both fractions with a common denominator and again missing out the intermediate step to lose the final mark. These students often forgot to multiply the two denominators as if they were forming an addition rather than multiplication.

Question 2

This question was very well done with the vast majority of students giving the correct 3 integers. Most of those who failed to get full marks gained one mark, usually for showing that the total of the four numbers had to be 36, either by explicitly writing 36 or, more usually, giving four numbers that summed to 36. Occasionally, students scored one mark for writing 4 numbers with a median of 8.5. Some students misinterpreted the three averages and then introduced range into the question.

A few students opted for a trial and error approach and some were able to reach the correct final answer. An often seen incorrect process was to write $\frac{7+7+8.5+13.5}{4}=9$. A common incorrect solution was 7, 8.5 and 1.5. Students should take care when reading the question; some stated the formula for the mean and then used 3 as the denominator despite 4 integers being stated in the question. The few students who chose not to show any method would have undoubtedly lost marks on this question.

Question 3

(a) The majority of the students gained full marks by representing the inequality on the number line. Some students lost the accuracy mark by not drawing the line between the two numbers correctly. It was encouraging to see that most students drew the correct circles at the two given numbers.

(b) Most students were able to list the correct integers for this inequality. Some students missed out a value, it was often zero or they added an extra number, usually −3.4 thus only gaining one mark.

Question 4

The majority of the students understood the concept of finding an average speed when given the distance and time. Errors were rare but, when they appeared, fell into one of two categories. Students either wrote 3 hours 24 minutes incorrectly as 3.24 rather than 3.4 or worked initially in minutes. Those who worked in minutes generally found an answer in km/min and then either did not realise the need to convert into km/h or else multiplied by 100 rather than 60 in an attempt to do so.

Question 5

(a) A majority of the students gained full marks on this question. It was encouraging to see the students show all their working. Many students found the value of x as 4.5 and then correctly substituted into the formula for the volume of the cylinder. Some students lost the final two marks as they did not use the correct formula for the volume of a cylinder, generally by using the formula for surface area. Sometimes student lost the final mark by leaving their answer as 182.25π. The question clearly says ‘Give your answer correct to the nearest whole number’.

(b) This part was generally well done. A majority of the students wrote their answer as 1 000 000 or 10^6. Some students simply wrote 1000 and gained no marks.

Question 6

(a) Many students realised that they had to either add 5*z* or multiply the whole equation by *y* and then rearrange for c to gain the two marks. However, some students made errors by just multiplying *A* by *y* and not multiplying 5*z* by *y*, thus losing both marks. Generally, this part of the question was answered well.

(b) A majority of the students wrote the correct answer as 1

(c) Many correct solutions were seen and the main error was to write an incorrect sign in the brackets such as $(x-3)(x+8)$ or $(x+3)(x-8)$ or $(x+3)(x+8)$; M1 was awarded for this. A few students went on to 'solve' their factorisation; this was ignored and so long as the correct factorisation was seen, full marks were awarded. Some students took *x* as a common factor for the first two terms and offered $x(x - 11) + 24$ as an answer which gained no marks.

Question 7

The majority of the students gained full marks, often using 1.024 as a multiplier. Some students stated the correct answer, 53687, but then subtracted 50 000 from it and gave the interest, 3687 as their answer; in this case they were not penalized and full marks were awarded. Simple interest was sometimes used, instead of compound interest; candidates who made this error generally scored 1 mark out of 3, usually for the interest earned at the end of the first year. In this examination series many students were writing $50\,000\times(1+2.4\%)^3$; we did not award marks for this unless it gave a correct solution. $50\,000 \times (1 + 0.24)^3$ was worth 2 method marks. Students are encouraged to write down the correct notation so that marks can be awarded for their correct method.

Question 8

Most of the students found this question straight forward. The majority either quoted 540° as the sum of the angles of a pentagon or found it using 180 × (5 − 2) and then divided by 5 to find the interior angle. In a similar way student quoted 720 as the sum of the angles of a hexagon or found it using 180 × (6 – 2) and then divided by 6 to find the interior angle. Some used the approach of finding the exterior angles of the pentagon and the hexagon. Some students could not recall $(n-2)\times180$ or use the method of triangles to work out the sum of the interior angles. As a consequence, many students scored no marks. It was not unusual for candidates to confuse the interior and exterior angles of a pentagon but still go on to obtain $x = 96$. Such responses received no credit, as did all who obtained the correct answer with spurious working or with no working at all. Many students who worked out 108° and 120°, then successfully worked out angle *EDI* (132°) correctly. Of the students who were able to make progress with the question and reach an intermediate value of 132°, a small number subtracted from 180, rather than 360 thus failing to apply their knowledge of the sum of the angles of a quadrilateral.

Question 9

There was some confusion between the HCF and LCM in parts (a) and (b).

(a) Some students worked successfully with the numbers given as products of primes; other students worked with the numbers themselves. A common correct answer given was 2 811 072

(b) This was generally answered satisfactorily but more students struggled with this part of the question. In a similar way to part (a) many students handled the powers well. It was pleasing to see most students set their work out clearly.

Question 10

Students frequently answered this question well. The most common approach was to use Pythagoras theorem to work out the height of the triangle. Many students worked out the height (4.89….) of the triangle and then went on to work out the area (24.494…) of a triangle. The area of the rectangle was usually found correctly but credit was not given to 60 m^2 on its own. Some students used the sine rule or cosine rule to find angle (x) of the apex or angle y $\left(=90-\frac{1}{2}x\right)$ then used $\frac{1}{2}ab\operatorname{Sin}C$ to work out the area of the triangle. Centres should continue to encourage their students to look for the simple solutions when solving problems. Many students then divided by 16 to find the number of tins used. Some students once they found the answer of 5.28… rounded down or did not round their answer to 6.

Question 11

(a) The cumulative frequency table was completed accurately by the majority with very few errors seen.

(b) The plotting of the cumulative frequencies was extremely well done, with the majority plotting end points accurately and joining with a smooth curve or line segments. Very few plotted mid points and only a very small number of students drew a 'squashed' cumulative frequency curve. A minority drew histograms or bar charts or a line of best fit.

(c) Most students were able to gain the mark for the median. It is important that students show clearly the method that they used to find the median. Candidates should be encouraged to draw in dotted lines from both axes at the point where the reading is being taken.

(d) Fewer students were successful in finding the number of people who waited 23 minutes or less. Some students who started to work out the number of people who waited , did not subtract this value from 120 so lost the marks. Many candidates failed to read the scale correctly, writing their values on the horizontal and vertical axis would help with clarity. Some, who misread the scale on the horizontal axis, started by drawing a vertical line at 21.5. It is important that candidates show clearly the method that they used to find the number of people who waited 23 minutes or less, along with full workings to calculate 120 minus this value as a percentage of 120.

Question 12

(a) This part was well answered and many students obtained the correct answer of $4e^5f^3$. The most common error was a failure to evaluate the square root of 16. Common incorrect answers were $16e^5f^3$ or $8e^5f^3$.

(b) Many students gained full marks for this. Errors included incorrectly expanding one of the brackets and changing the denominators to 7 rather than 12. Some worked with no denominator at all whilst others worked exclusively on the numerator before introducing the denominator later. A common incorrect approach was to write $3(2x+1)+4(x-2)$ and then state the answer as $10x-5$ but for this no credit was given.

(c) Most students who could transform the equation to powers of 2 or 4 or 16 were successful in completing the solution. Some used trial and improvement which was not a valid method to award marks. Students should use an algebraic process to find the value of *k*.

Question 13

Many correct answers were seen here with workings often shown on a diagram. Those that were not correct often added the given vectors together or multiplied them.

Question 14

Students struggled to find a correct start to this question. Many were thrown off by the quadrilateral to which they tried to apply the alternate segment theorem, stating incorrectly that *DFE* or *BDF* = 39. Even if they continued to reach an answer of 123 no marks could be gained as this was from incorrect working.

Some students drew a line from *B* to *E* and then used the alternate segment theorem to find angle *BED* as 39 or correctly used angles in the same segment to identify the angle *DBE* = 18. A few students marked the centre of the circle and then correctly used the angle at the centre being twice the angle at the circumference.

Many students who worked out that angle BFE (39 + 18 = 57) realised that they had to use one of the circle theorems (opposite angles in a cyclic quadrilateral sum to 180°) then went on to work out angle *BDE*.

Students who made assumptions, such as using *DF* as the diameter of the circle, gained no credit unless they first gave full explanations for their assumption.

The answer of 123 was commonly seen but relied on a correct method, which many students did not provide, often not identifying the angles they were referring to.

Many students scored the first 3 marks but often omitted one of the reasons entirely or else incorrectly stated or abbreviated the required reason, resulting in the loss of the final mark.

Students must use precise language when explaining reasons and avoid abbreviations in order to gain B marks.

A very few number of students achieved full marks on this question.

Centres should try and encourage their students to answer these questions in a logical fashion:
Mark each angle on the diagram when found.
Label each angle clearly in the body of the working.
Describe each theorem alongside the appropriate method as it is used.

Question 15

(a) The most successful candidates were those that chose x = 4.57 and 100x = 457.57 leading to $\frac{453}{99}$ etc. The question clearly states that an algebraic approach is required so students who did not write, for example, x = 4.57 and 100x = 457.57 did not gain any marks. A common error was to use their calculator and this scored no marks.

(b) Marks on this question were well spread with less able students struggling to start. Many students did write down a correct expression to multiply both numerator and denominator by the same correct expression. $6+3\sqrt{2}$ was the expected choice but some used $-6-3\sqrt{2}$ instead. The more able students were able to expand the numerator to obtain 2 correct terms. Some students did not correctly simplify the numerator and denominator so lost the final accuracy mark. This was a challenging question. Often students used an incorrect expression to multiply numerator and denominator by, with $6-3\sqrt{2}$ commonly seen, as well as $3\sqrt{2}$.

A significant number of students used their calculator to reach the answer straight away, and if they did not show the steps of the working, as requested in the question, they scored no marks.

Question 16

(a) The more able students scored well on this part of the question requiring the expansion of a product of three linear expressions to give a fully simplified cubic expression. Errors were usually restricted to incorrect terms rather than a flawed strategy, although some students omitted terms from their expansion. It was usual for students to earn two or three of the available marks. Less able students lacked a clear strategy and sometimes tried to multiply all three brackets together at once. Several students failed to use brackets in the first stage of their multiplication which sometimes led to errors in the algebra. Students should be encouraged to use brackets to clearly indicate all of the terms being multiplied.

(b) Many students gained full marks on this part of the question. Some students worked out the correct answer as $(x-5)^2+15$ and then went on to state that a = 5 and b = 15, this was condoned. Only a few students equated coefficients and found the correct values for *a* and *b*.

Question 17

These types of questions come up frequently and students generally know what is required. The students sitting this paper were no exception, most of them showing clear algebraic working and gaining a set of correct answers. Those who didn't score full marks generally gained 1 mark for showing a correct substitution but were unable to expand the bracket correctly, or 2 marks for getting to the correct three term quadratic but being unable to solve it by either factorisation or use of the formula. Many students made algebraic errors whilst trying to eliminate one of the variables or in the resulting algebraic manipulation after a successful elimination of a variable.

A common error was to expand $y(6y + 5)$ as $6y^2 + 5$. A few insightful students multiplied the linear equation by y, for example, $xy - 6y^2 = 5y$ and subtracted the two equations then (correctly) found the quadratic equation $4y^2 + 5y - 6 = 0$

Where there are two pairs of solutions students should ensure that they correctly pair the values of x with the values of y.

It is clear that students who set out their work neatly and in a logical order are less prone to making errors when solving complex questions such as these.

Question 18

For able students it was relatively easy to spot that 1 cm^2 represented 2 students, or to work out the frequency density value of 14. Students should appreciate that labelling the frequency density axis correctly can usually pick up a mark, even if mistakes occur elsewhere. For weaker candidates the unequal widths in the blocks was a source of problems as well as not writing a scale on the vertical axis. Many students did not understand that the frequency is proportional to the area, not the height of a bar in a histogram and many did not have a correct method to find the frequencies.

Students who calculated the correct frequencies successfully, usually went on to achieve full marks by finding the correct mean. A common incorrect answer for the frequencies was (28), (40), 60, 48 and 24. It was reassuring that many students were able to gain two marks by correctly using the mid points and their frequencies to find the mean, however, thus losing the final accuracy mark.

A common error by some students to find the mean was to use the upper limits to work out $\sum fx$ and then dividing by 5.

Question 19

The correct reasoning process needed to answer this question was $\frac{t_{LB}}{a_{UB} - h_{LB}}$. Responses tended to fall into three groups (i) students who followed the processes shown above (generally gained full marks), (ii) students who knew something about lower bounds and upper bounds but could not apply the reasoning correctly (1 or 2 marks) and (iii) students who had little or no idea of bounds (those who worked out an answer using exact values and then took the lower bound of this exact value).

Common errors made by students were to write $\frac{13.5}{7.85-7.45}$ or $\frac{13.5}{7.75-7.35}$. Students did not realise that to get the largest difference for the denominator was to work out $a_{UB}-h_{LB}$ or 7.85 – 7.35.

Question 20

Students who understood that they needed to differentiate the given expression for displacement in order to find the velocity and then differentiated again to find the acceleration generally gained full marks. Frequently students differentiated to find the velocity and then did not know what to do for the next step. Some at this point equated their velocity expression to zero and attempted to solve the quadratic. An occasional error was to get $3t^2 - 18t$ rather than the correct expression $3t^2 - 18t + 33$.

Some students used the method of completing the square after they had found $v = 3t^2 - 18t + 33$ and did not realise that the minimum speed of P was 6 m/s thus losing the final mark. Others divided the expression by 3, which was an incorrect method and lost them the subsequent marks. Another approach employed by some students was to use $t = -\frac{b}{2a}$ to find $t = 3$ and then substitute this value into $v = 3t^2 - 18t + 33$ to find the minimum speed of P. Once they had found $t = 3$ some then substituted this value into $s = t^3 - 9t^2 + 33t - 6$ which was incorrect.

In general, a clearer understanding of the links between displacement, velocity and acceleration is needed.

Question 21

There were a fair number of blank responses on this high-grade question as many students found this problem challenging and difficult. Students whose algebraic skills were excellent could proceed to gain full marks. Some students gained the first mark by forming the equation $a + 3d = 6$. Many students could not set up the next equation, $\frac{11}{2}\left(2a+10d\right)=(a+5d)^2+18$, as some recalled the sum of the n terms incorrectly even though it is given on the formula sheet or forgot to square $(a+5d)$. It was quite rare to see a correct quadratic and in particular a correct answer.

Some students used strange methods to come up with actual values for a and d, for example, $\frac{6}{4} = 1.5$, by interpreting $U_4 = 6$ incorrectly or $U_4 = 6$ so $U_{20} = 5 \times 6$, thus not gaining any marks.

Generally, this was a question where clear layout was essential. Those students that took care to present their work in a logical way were often successful, whereas where working was muddled, students often lost their way and also lost the marks they might otherwise have gained.

Question 22

A large number of students did not know how to start this question. Although we were pleasantly surprised at the number of correct solutions seen. Many students failed to find the gradient of *BC* $\left(=\frac{5}{3}\right)$ and then could not recall that the perpendicular gradient can be worked out using $m_1 \times m_2 = -1$. Some students gained 1 mark by finding the midpoint of *BC*. Many students could not recall the method of finding the equation of a straight line or if they did, they often used $\frac{5}{3}$ rather than the perpendicular gradient of $-\frac{3}{5}$. Students should read the question carefully as some did not write p, q and r as integers and left their answer as, for example, $y+\frac{3}{5}x=\frac{39}{5}$ thus losing the final mark.

Summary

Based on their performance in this paper, students should:

- be able to work out the sum of the interior angles of a polygon
- be able to interpret bounds
- be able to apply differentiation to kinematics
- be able to find frequencies from a histogram
- read the question carefully and review their answer to ensure that the question set is the one that has been answered
- make sure that their working is to a sufficient degree of accuracy that does not affect the required accuracy of the answer.
- students must, when asked, show their working or risk gaining no marks despite correct answers

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