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Examiners' Report

Principal Examiner Feedback

Summer 2022

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In Further Pure Mathematics (4PM1)

Paper 01R

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Introduction

It was pleasant to note that the turmoil of the recent years seems to have passed and that the general standard of candidates' work was similar to pre-pandemic levels. There were some excellent scripts submitted in this series, and it was also pleasing to note that the less able candidates were also able to score marks on the questions at the start of the paper, and also some marks on the later questions. Questions 10 and 11 p[arts (b) and (c) in particular tested the most able, and yet there were a good minority of candidates who tackled these with aplomb.

Question 1

This first question generally gave a very accessible start to the paper.

Many fully correct answers were seen, with a variety of methods seen; though forming simultaneous equations with t_5 and t_{100}, solving for a and d and then substituting into S_{50} was the most popular. The occasional candidate assumed that this was a geometric series, but this was very seldom seen.

Most students were able to form the two linear equations for the 5th and 100th terms and then most students went on to solve their equations for a and d.

Most students used the summation formula $S_n = \frac{n}{2}\left(2a+\left(n-1\right)d\right)$ and for the most part substituted correctly to gain full marks. The alternate approach to find the 50th term then the first plus last summation formula was seen and for the most part this was applied accurately. A few responses having found the 50th term correctly, stopped working and omitted to use it to find the sum.

Question 2

(a) Virtually every candidate was able to find the expression successfully for the acceleration.

(b) Integrating to find the displacement was generally very well done. The main error was to neglect to include the constant of integration when substituting $t = 2$ to obtain the value of c and thus the correct full expression for the distance. Thereafter, substituting $t = 4$ and obtaining the displacement $\frac{47}{3}$ was routine for most. Integrating using limits was also occasionally seen, though this approach was less successful.

Question 3

(a) The majority of candidates were able to use the correct radian area formula to obtain the angle $\frac{\pi}{4}$, although degrees were occasionally seen. It was rare to see a candidate attempting to work in degrees, although we did credit an angle of 45° seen with the M mark. Most candidates knew the formula for the area of a sector and were able to apply it fluently.

(b) The formula for arc length was generally used appropriately and candidates were able to obtain the arc length 11.1 (cm). This was again very well completed, although working in degrees was sometimes seen. A minority of candidates forgot that the perimeter was asked for and did not incorporate the lengths of the two radii *OR* and *OS*.

(c) Finding the area of the triangle using the appropriate formula and equating it to 2π and obtaining an exact answer was generally far less well tackled. A significant minority of candidates erroneously assumed triangle *TOS* to be right-angled at the point *T*. *TS* was then calculated using Pythagoras theorem or right-angled triangle trigonometry, and area *OTS* found as $\frac{1}{2}\times OT\times TS$. A few candidates did not read the instruction to give an exact value of *A* and gave an answer of 4.868…. which could only score the M mark. If both the exact answer and an approximation was seen, we of course, awarded both marks here.

Question 4

(a) (i) & (ii) It was very rare indeed to find an erroneous expression for either the area or the perimeter.

(b) This part was really two sub parts; the handling of the inequalities was well done and there were virtually no errors in solving $4x+8<30 \Rightarrow x<\frac{11}{2}$. The quadratic inequality was also generally correctly solved, with the two critical values of $x=2,-6$ obtained usually by factorising the quadratic equation resulting from $x^2+4x>12$. Less able candidates confused their solutions to the quadratic inequality and the use of – 6 in the final answer was seen on a regular basis , without realising that the inequalities needed to be combined. More than a few candidates did not realise that a length cannot be a negative value, and so did not discard the value of -6 lacking the appreciation that it could not possibly be correct.

Question 5

(a) The Product Rule for differentiation was very well known and employed accurately. Mistakes were made through mainly forgetting to multiply by 6 when differentiating $(6x+2)^{\frac{3}{2}}$ or forgetting to multiply by 4 for the derivative of e^{4x}. In the question, stating the form of the answer put some less able candidates off and many struggled because they were unable to take $\sqrt{6x+2}$ out correctly as a common factor. M1A1A1M0A0 was the common scoring pattern for this question.

(b) Using the quoted Quotient Rule was generally well understood with errors mainly in wrongly differentiating $\sin 3x$ or $(2x-4)^3$. The denominator was mostly correct and many candidates scored full marks here. There were some unsuccessful attempts to simplify the differentiated expression, but candidates should realise that unless they are specifically asked to simply an answer, there is no need to carry on algebraic manipulations. We did not penalise erroneous attempts to simplify but scored the marks on a correct un-simplified derivative when it was seen.

Question 6

(a) Rationalising the denominator was the more popular option, though cross-multiplying and comparing coefficients seemed to provide the easier option. Virtually every candidate managed to find the value of *a* correctly.

(b) The Sine rule was generally applied to the triangle successfully, resulting in a linear equation in *x*. Thereafter factorising, with square root terms was a struggle for some and rather than rationalise $\sqrt{2}-1$ by multiplying the numerator and denominator by $\sqrt{2}+1$ a number of candidates resorted to simply giving the given answer which could not score more than the first M mark.

(c) The answer to this part of the question was generally substituted into the correct formula for the area along with the given sin 105° and after some arithmetic with roots a final answer in the correct form obtained. Errors were mainly made in the arithmetic, though some correct answers were seen.

Question 7

(a) Only the more able candidates were able to draw the correct graph with the correct intercepts. A number of candidates drew the graph with domain [-1], and but a number did not appreciate the asymptotic nature of the curve at $x = -2$. It is a good tip for candidates to show the asymptote using a dotted/dashed line to help them draw the curve.

(b) This part of the question was generally very well done with many achieving the required value of 4096. A small minority of candidates made mistakes when applying the log power rule.

(c) An equation in log to base 2 or log to base q was usually obtained correctly by a change of base and thereafter a 3TQ formed, factorised (or otherwise solved) and successfully solved to find two values. Once again, less able candidates were unable to manipulate logs correctly and struggled with this question which was otherwise well done.

<u>Question 8</u>

(a) Most were able to obtain this fairly efficiently although some expended much working on it. It seemed of little avail as hardly anyone seemed to relate it to the next part of the question and subsequently many did not relate it to $x^3 + y^3$ in part (b) of this question. The algebra involved in expanding $(x+y)^3$ proved a surprising struggle for a minority of candidates, whereas others simply just wrote it down.

(b) Very few errors were seen in stating the values for the sum and product [and, indeed, for the constant in (c)]. Many were able to state the identity given in the mark scheme. Others tried to use algebra to obtain this or other such identities with varying degrees of success. The occasional arithmetic or sign error was not uncommon. Most candidates correctly found the required sum and product of the roots and henceforth used their own expression for the sum of the cubes of the roots. Occasionally a wrong expression was used. Thereafter, a correct substitution into a correct rearrangement provided the correct answer.

(c) Many candidates were successful here. Most were able to successfully find the algebraic form for the sum and product, and substitute in the necessary constants. The understanding to form the required quadratic equation was clear, although as reported in many previous series, some omitted the zero or ignored the requirement for integer coefficients. Algebraic errors were seen but apart from slips in forming the sum or product of roots, the main errors being;

- not using – (sum of roots) for the coefficient of the x term and
- not forming an equation by equating to 0.

Question 9

(a) The first 2 marks were nearly always gained except for those who wanted to reverse the vectors. Most managed to give a correct multiple although sometimes they had $\overrightarrow{AB}$ as the smallest multiple or missed out any reference to the vectors being parallel. Some multiplied $\left(4\mathbf{a}+\frac{4}{3}\mathbf{b}\right)$ by 3 and then had that as the "biggest" vector.

Generally, the method of finding the vectors for $\overrightarrow{AB}$ and $\overrightarrow{DC}$, and then comparing them was well understood. There were several responses in which candidates inexplicably found the vectors $\overrightarrow{BA}$ and $\overrightarrow{CD}$ which could not score the first two marks. We allowed these candidates to recover the next two marks if they were able to show that they are multiples of each other and are therefore parallel, despite being in the incorrect, or sometimes even opposite directions. If there was a conclusion, the quality and variety was varied but some excellent reasoning was also seen.

(b) In this part of the question the first two marks were often gained very easily, and sometimes the third for the vector $\overrightarrow{AC}$, although this was the one that was most likely to be incorrect. About half managed to solve the equations and found a value for the parameter. When this was found then the majority $\overrightarrow{AY}$ found correctly. However, it should be noted that there were many blank responses to this part of the question.

The majority of candidates followed the conventional route of finding $\overrightarrow{AY}$ as for example, $k\,\overrightarrow{AC}$ and taking either of the routes $\overrightarrow{AY}=\overrightarrow{AB}+\mu\,\overrightarrow{BY}$ or $\overrightarrow{AY}=\overrightarrow{AD}+\varpi\,\overrightarrow{DY}$ forming simultaneous equations from equating the vector components of **a** and **b** and solving for the parameters to proceed to find $\overrightarrow{AY}$ successfully. Errors usually occurred in wrongful vector additions or when solving the simultaneous equations for the parameters. Occasionally invalid routes for $\overrightarrow{AY}$ were taken and compared.

Question 10

(a) There were many non-responses for this question, perhaps more than any other question. However, those attempting it usually managed to use both identities and found that this part of the question was considerably easier than appeared at first sight.
The use of the quoted formulae, however, to show the required result proved a challenging exercise for many candidates.

Candidates who started with $\sin(A + B)$ and $\sin(A - B)$ and tried to equate them or set $\sin(2x + 2x)$ for example, were not able to recover. Some candidates chose to use other trigonometrical identities which were not relevant.
The successful responses were able to see the split for $5x$ as $4x + x$, and for $3x$ as $4x - x$ and defined the correct approach of $\sin(A + B) - \sin(A - B)$ which then very easily led to the cancelling of the two $\sin A \cos A$ terms to show the required solution.

(b) In most cases, and even then for the minority of candidates who attempted this question at all, the only marks often gained were the two available for the integration. In fact the most common marking pattern in this question was M0M0A0M1A1M0M0A0 or 2 marks out of 8. The first 3 marks for the intersections were often missed completely with very few setting $\sin 4x \cos x = 0$ and then solving to find the required angles within the specified range between $x = 0$ and $x = \frac{\pi}{2}$ Those who did find the limits usually got the correct area but these were very few and far between. Some candidates as usual found a value of 3.86 from entirely erroneous or no working; the result of using a sophisticated calculator. As the question clearly states 'using a calculator' writing the answer down with no, or incorrect working always resulted in no marks.

Integration of $\sin 3x$ and $\sin 5x$ was generally well done and the use of limits in the integrand well understood. Where candidates realised the integration had to be done in two parts, substitutions and calculations were generally accurate; including allowance for the negative area and the multiplier of 3.

With the omission of the interceptions, the limits of the integral were seldomly seen.

Occasionally responses were able to show the correct limits without evidence from setting $\sin 4x = 0$ or $\cos x = 0$ and, as the mark scheme allowed this, all marks were recouped from this stage. From here though, following correct substitutions, errors were made in evaluation, often the use of the modulus was not seen.

Only a tiny minority of candidates produced a fully accurate and complete answer to gain all 8 marks.

Question 11

This was another question with many non-responses but there were not as many blanks as we found in Question 10. Sometimes the only marks obtained were the first three marks in (a) and the first mark in (b). However, there were many who managed to complete part (a) successfully. Hardly anyone forgot to write down the correct equation in the required form as the last line. In part (b) many managed to get an equation in p and q but often couldn't get any further getting to an equation only in either p or in q. Part (c) had lots of strange values for the y coordinates of E and F.

(a) This was the best answered part of this question, with many candidates who attempted this question gaining full marks. .Most candidates were able to find the value of b by correctly substituting the x value of 10 into the equation of l. At this point most also found the coordinates of A (0, 3) and drew a diagram. Those that did draw a diagram were more successful. Centres should urge their students to draw a diagram every time on this type of question. A reasonable sketch labelled carefully, can be invaluable in guiding candidates to correct solutions. Once they had the two points, A and B, many candidates were able to use them correctly with the ratio to find the coordinates of C, the midpoint of AB with coordinates (4.15). The gradient of $-\frac{1}{3}$ was found very well by almost every candidate. The equation of a straight-line formula $y - y_1 = m(x - x_1)$ is generally the more efficient way of finding the equation of a line because marks are scored immediately for correct substitution. Using $y = mx + c$ requires a candidate to find a value for c before marks are scored.

(b) This was not so well answered, with the majority only gaining half of the 6 available marks.

Almost all candidates obtained the first mark in this question however, for finding the coordinates of the y-intercept, A. In almost all cases this was found at the start of part (a) but which was awarded here. Some were then able to correctly find an equation for the gradient, by equating a correct gradient expression in terms of p and q and equating it to $-\frac{1}{3}$. There were a few candidates whose gradient expression was written in terms of x and y. Centres should advise students of the importance of defining variables correctly because this has the effect of confusing candidates. To score this method mark most candidates were able to use either the gradient equation or use Pythagoras correctly to form an equation in p and q using their y-intercept coordinate A and equating this to $\left(12\sqrt{10}\right)$ or 1440. However, the next method mark and hence the rest of the marks in this question were not easily obtained by many candidates, with some only getting this far and getting no more marks. For those who did not score any further marks, this was usually because they only had either an equation using the length, or an equation using the gradient, but not both, and were therefore unable to form a quadratic equation in just one variable by eliminating the other.

Candidates who were able to form a 3TQ in terms of p were more likely to identify p incorrectly as $p = 36$ instead of -36 and thus lose the last two A marks. In these cases, candidates who moved directly from $p^2 = 1296$ to $p = 36$ were likely to miss the correct value of x of – 36, whereas those candidates who noted $p = 36$ **or** – 36 were then more likely to reject the positive value.

(c) Few candidates scored any marks at all in this part of the question. Those who did, put the value found for p into the line k and find the coordinates of E for the first method mark and similarly into l for the coordinates of F.
The area of the triangle was not done well at all. This was often because candidates did not have a sketch to refer to and did not realise that the points D, E and F were all located on a vertical line [with equation $x = -36$] and could have used a very simple method to find the area of the triangle. Candidates using method 3 on the mark scheme $\left(\frac{1}{2}\times\text{base}\times\text{height}\right)$ were usually very successful and scored all three marks if their coordinates for E and F were correct, or otherwise M1M1A0 if they were not. Method 2 in the scheme [discriminant method] were able to get the first M mark for a correct array, but then there were frequent errors in signs and the order of multiplication, and so lost the final two marks. This method of finding areas in coordinate geometry seems to the default method and is used even where use of $\left(\frac{1}{2}\times\text{base}\times\text{height}\right)$ is not only far simpler, but also much more appropriate.

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