Pearson Edexcel

Principal Examiner Feedback

Summer 2018

Pearson Edexcel GCE A Level Mathematics

Pure Mathematics Paper 1 (9MA0/01)

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Introduction

This was the first A level Pure paper for the new specification. The paper seemed accessible to the vast majority of students. The paper stretched the brightest of students but gave less able students the opportunity to score a reasonable number of marks. Centres had clearly prepared their students for the new style questions with good responses seen on questions 1, 7 and 12 although a lack of understanding in the required demand of question 4 was evident.

Students need to take care in writing down their answers to 'modelling' questions. In question 8, for example, units were required to score marks in both parts of the question.

The answers to questions requiring explanations were often the weakest. Clearly this will improve over time as centres gain more experience in preparing students for this type of question. There were many examples where students had a vague idea of 'the answer', but many were unable to express themselves with sufficient accuracy or clarity to gain any credit. This was particularly relevant in questions 2, 4 and 9.

Comments on individual questions

Question 1

This question was accessible to most students and many gave fully correct solutions. Almost all students were able to score a mark for $\sin 3\theta \approx 3\theta$ but there were a number who simplified the denominator to 6θ instead of $6\theta^2$ resulting in a final solution of $\frac{4\theta}{3}$. Replacing the $\cos 4\theta$ proved more problematic with common incorrect attempts on the numerator including $1-4\left(1-\frac{\theta^2}{2}\right)$ and more frequently $1-\left(1-\frac{4\theta^2}{2}\right)$ where the 4θ was not squared leading to an incorrect answer of 1/3. Other common incorrect attempts involved simplifying $1-\cos 4\theta$ to $-8\theta^2$ rather than $+8\theta^2$ leading to the incorrect answer of - 4/3. Even in cases where both substitutions were performed correctly many careless errors were made when simplifying. There were a small number of students who tried to expand and simplify the expression using the double angle formula for $\cos 4\theta$, but in most cases this resulted in an incorrect expression which did not lead to the correct answer.

Question 2

Part (a) of this question allowed the demonstration of good skills in differentiation and was well answered by the majority of students. A small minority made careless errors on the indices, for example writing $\sqrt{x}$ as x^{-2}, leading to the loss of both marks as their derivative was not of the required form. Others dealt with the index correctly, but made arithmetic errors on the coefficient when differentiating the term. The second derivative was almost always either correct, or a correct follow through, from the students first derivative.

In part (b) a significant number of students were seen attempting to solve the equation dy/dx = 0 although most quickly realised that they could substitute x = 4 into dy/dx to obtain 0. To be awarded the final mark of part (b), students were required to interpret their value of dy/dx at x=4 and conclude that the point was a stationary point of the curve. Many students omitted this final step thus failing to fully answer the question.

For part (c) there was a little more variation. Most students were aware of the need to substitute $x = 4$ into their second derivative and evaluate its sign, although some failed to do this and instead considered the sign of either y, dy/dx and/or d^2y/dx^2 either side of $x = 4$ (usually at 4.1 and 3.9). A follow through mark enabled students with an incorrect negative or fractional index from part (a) to achieve both marks in the last part of the question. A significant proportion of students seemed unable to interpret what they had proven from their calculations, and many seemed to think they were looking for an inflection point, or else determining that the curve was either convex or concave. As with part (b), the most common source of lost marks was therefore a lack of correct reasoning before making a conclusion.

Question 3

This question was well answered by the vast majority of students. The formulae for arc length and area of a sector were well known and applied, and although the 4 was occasionally seen on the incorrect side of the equation, this was rare. Most students worked in radians and used simultaneous equations to find the value of θ before proceeding to find an exact (positive) value

for r. Algebraic and numerical slips, however, when manipulating equations were not an uncommon reason for losing marks. If method errors were made in this question, it was usually to miss the half from the sector area or to confuse the area of a sector with that of a triangle.

Question 4

This was perhaps the most poorly attempted question on the whole of the paper. Part (a) should have been familiar to centres but one which required the students to set up their own function, usually $\mathrm{f}(x) = 2\ln(8 - x) - x,$ before substituting in the x values of 3 and 4. This was well done, but also quite commonly, the only mark gained in the question. To show that $3 < \alpha < 4,$ a student needed two correct calculations, give a valid reason, which required both a change in sign and a mention of continuity, as well as giving a brief deduction. Explanations rarely mentioned the fact that the function needed to be continuous in this interval. Fully correct solutions to part (b) were very rare. Many students assumed that this was a question on continued iteration and gave all values of x from x_1 to x_8 without any consideration of the demand of the question. Students were required to **"use the graph"** to show whether or not the iteration formula could be used to find an approximation for α. Hence, to satisfy this demand, a cobweb diagram starting at $x_1 = 4$ was required followed by an explanation that "it can be used" because "the cobweb spirals inwards towards α.

Question 5

The majority of students knew to use the quotient rule in this question, although the slips on signs and bracketing in the terms of the numerator were commonplace. We would encourage all students to state the formula being used, with their expressions for '*u*' '*v*' 'd*u*' and 'd*v*', to ensure that their method is made clear to examiners.

Getting a correct derivative into the required form using trigonometric identities proved to be more challenging than the differentiation in this question. Students recognised the need to use the Pythagorean identity for sine and cosine to simplify their numerator and denominator but were less confident when applying the double angle formula for sine, and it was not uncommon for a final answer to be left as $\dfrac{3}{2 + 2\sin 2\theta}$, or for there to be errors in an attempt to write this fraction in the required form.

Question 6

Part (a) was a "show that" question in which students used the idea of perpendicular gradients to find the equation of line *PA*. It was very straightforward and well done with almost all students scoring the 3 marks. Part (b) required the students to find the equation of the circle *C* using the information given. Again most students attempted this with ease, finding firstly the coordinates of point *P*, and then the radius *PA*, before writing down the equation of the circle. Errors witnessed tended to be arithmetic, although some students complicated the question by attempting to solve $(x-7)^2+(y-5)^2=r^2$ and $y=2x+1$ simultaneously in an attempt to find *r*. There were numerous ways to find the value of *k* in part (c). One of the best involved using vector geometry to find the coordinates of the point *N* on *C*, where $y=2x+k$ meets *C*. Using the fact that $\overrightarrow{PA}=\overrightarrow{AN}$ enabled students to find *N* = (11,3) and then *k* by substituting this point into $y=2x+k$. Again simultaneous equation methods were common, some more successful than other. The most common correct attempt involved solving $y=2x+k$ with $(x-7)^2+(y-5)^2=20$ and then finding where the resulting equation had one root. Care was required with the algebra, especially the squaring of terms, as well as the application of the discriminant $b^2-4ac=0$. This proved to be too great a challenge for many.

Question 7

Both parts of this question were answered well, allowing students to demonstrate their confidence in integrating fractional expressions in *x* and working with unknown constants. The majority of students failed to make any statement regarding the integral in (a) being independent of *k*, or in (b) inversely proportional to *k*. Whilst not a requirement for the final A mark in either part, the logical completion of the question would have been to make these conclusions and show an understanding of these mathematical terms.

Common method errors in this question included integrating to obtain a natural logarithm in part (b) as well as part (a). Additionally, despite the successful implementation of limits, some careless and disappointing algebra was seen in simplifying their final expressions in an attempt to answer the question.

A more unusual but not uncommon error was related to the fact that '*k*' occurred both in the integral and in the limits. Some students integrated with respect to *k* whilst others substituted the limits for the term in *k* rather than the term in *x*. Other unusual attempts were seen by students attempting to use partial fractions within part (b).

Question 8

This question involved modelling the depth of water in a harbour using a trigonometric function. The mark in part (a) was usually scored, although some students did forget to include the units for the answer of 4.48 metres. Other errors seen were as a result of substituting incorrect values of t , usually $t = 0$, into the equation for D or prematurely rounding their answer to 4.5 metres.

Most students also started part (b) correctly and were able to proceed to the intermediate point of $\sin 30t = -0.6$ without much difficulty. The final part of the question, however, proved to be much more difficult, with many students not finding a value of t greater than 8.5, giving $t = 7.2$ then a time of $7{:}14am$. Of those who correctly found $t = 10.77$ a large number failed to give their final answer as a time, with 10 hours and 46 minutes being common. A number of successful students were noteworthy in terms of the clear presentation and communication of their solutions, often producing sketch graphs of the sine curve to aid their understanding.

Question 9

Question 9(a) was well answered. Students generally demonstrated a good understanding of implicit differentiation as well as the chain and product rules. Most reached the given result scoring all 4 marks.

In question 9(b) however, many made the numerator of the fraction equal zero (i.e. $y = x$) instead of the denominator ($x = 3y$). This kind of error usually resulted in only two of the five marks being scored. There were however many full and accurate solutions, with very few students unable to pick out the coordinates of the point P from the two solutions to their simultaneous equations.
Only a small number of students gained the B1 mark in question 9(c). They simply needed to state that the point furthest north can be found by substituting $y= x$ into the equation of the curve and picking out the positive solution. Explanations tended to be incorrect or incomplete, with many stating that it could be found by putting either $x = 0$ or $y = 0$.

Question 10

This was another modelling question, this time modelling the height of a roller coaster above the ground by a differential equation. In part (a), the majority of students were able to separate the variables of H and t and thus integrate both sides. Integrating $\cos 0.25t$ was done well with most dividing by 0.25 or multiplying by 4. Almost all students were then able to proceed with ease to $\ln H = 0.1\sin(0.25t)$. The last two marks proved harder to score. Quite a sizeable proportion of students failed to include the constant of integration in $\ln H = 0.1\sin(0.25t) + c$ and so were unable to apply the boundary condition $t = 0, H = 5$ in an attempt to find c. The final mark was the hardest to gain. The answer was given and many students merely copied down the result on the examination paper. There had to be clear evidence that the constant they found was processed correctly and that their log work was sound. The requirement of at least one correct line of working between their working and the given equation, with no incorrect working, was fair to those who showed a clear argument.

Part (b) was found by almost all students, even those who could not attempt part (a). In this case the exact answer $5e^{0.1}$ was accepted as well as 5.53 metres. Fewer students scored both marks in (c), but many were aware that it would occur when $\sin(0.25t) = 1$. The most common errors were to find the first value using $\frac{\pi}{2}$, or else use 450 rather than $\frac{5\pi}{2}$, thus arriving at the incorrect answer of 1800 seconds.

Question 11

This question on the binomial expansion was well attempted by many students, although showing sufficient detail to prove the given result in part (a) and providing a comprehensive explanation in part (b) proved difficult. In part (a), the majority of students started by attempting to expand $(1+4x)^{0.5} \times (1-x)^{-0.5}$. As mentioned in previous years, it is good practice to give the unsimplified version (of each expansion) before attempting to find the simplified form. Those who did find the correct simplified forms of both expansions often lost the last two marks as many proceeded to just write down the given answer. This is a show that question and there was a requirement to show the six key terms that when collected together formed the given expression. Strangely there were a number of cases where the correct expansions were added, and in other cases divided, in an attempt to find the given answer.

As with other "explain" questions on this paper, (b) was the worst attempted part of the question. Many merely pointed out that 1/2 was too big or could not be used to find $\sqrt{6}$, rather than focussing in on the range in values of x for which the expansion was valid.

Part c was the most successful part of this question for many students with many gaining all three marks. Errors seen were mostly arithmetic, with the incorrect fraction $\frac{1183}{968}$ commonly seen

Question 12

This question, based upon the formula $V = ap^t$, modelled the value of a car in £'s against the time in years after 1st January 2001. Part (a) was very well answered by the majority of students. Most chose the correct values of t and V and successfully solved a pair of simultaneous equations. Common errors involved using incorrect values for t or failing to show that A was approximately
24 800. It is important in answering questions such as (b) that students are precise about the language and words that they choose. For example, for (b)(i) the statement was required to reference "the car", "its value" and the "initial time". In part (b)(ii), "the amount the value of the car was increasing by" was common and scored 0 marks. For this part, a clear answer would be "it is the rate at which the cars value is increasing each year" or "the cars value is increasing by 6.6% a year".

In part (c), students generally scored the first 3 marks by correctly using logarithms and proceeding to t =21.8 or 21.9. Most students then thought that the year must be 2023 instead of 2022 as they had rounded 21.8 to 22 and added it to 2001.

Question 13

This was an open ended question on integration. The three most common methods seen are shown the mark scheme, two methods using substitution and one using integration by parts.
Integration by parts was popular and well understood by the majority of students. Most knew that $\int\sqrt{x+2}\,\mathrm{d}x \to \frac{2}{3}(x+2)^{\frac{3}{2}}$ and were able to integrate to an expression of the form $Ax(x+2)^{\frac{3}{2}} - C(x+2)^{\frac{5}{2}}$ Slips in the values of the constants A and C were rare. However, as with earlier questions, there was a lack of clarity in moving from $\left[\frac{4}{3}x(x+2)^{\frac{3}{2}} - \frac{8}{15}(x+2)^{\frac{5}{2}}\right]_0^2$ to the given answer of $\frac{32}{15}\left(2+\sqrt{2}\right)$
Substitution was also well understood with $u = x+2$ more common than $u = \sqrt{x+2}$. Errors here included the omission of finding $\mathrm{d}x$ in terms of $\mathrm{d}u$, poor expansion of expressions such as $2(u-2)\sqrt{u}$ within the integral, and, as with parts, a lack of acceptable working shown when proceeding to the given answer.

Question 14

The final question on the paper was a challenge to all. Part (a) was straightforward with most recognising the need to use the identity $\cos 2t = 1 - 2\sin^2 t$ in some form to prove the required result. This was one of the more successful "show that" parts of the paper.
Only stronger students, however, were able to understand and explain why the curve C did not include all points of the curve $y = 6 - (x-3)^2$. Many drew the whole of the parabola in part (b) scoring one out of the three marks. Those who managed to sketch the correct part of the parabola rarely were able to explain why the domain (and range) were restricted. Stating that "because $0 \leq t \leq 2\pi$ " was not enough to explain why for instance $1 \leq x \leq 5$. The best students were able to explain that as $-1 \leq \sin t \leq 1$ then $3 + 2\sin t$ would have a maximum value of $3 + 2 = 5$ and a minimum value of $3 - 2 = 1$.

Part (c) was also demanding and better students annotated their graphs to help their understanding of the question (See Figure 1). Most however used the discriminant condition $b^2 - 4ac > 0$ for two roots and were able to proceed to two values. Arithmetic errors were quite common using this method. Most students who proceeded to the answer were well versed in writing their answer using set notation.

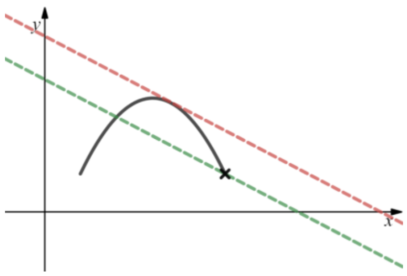

Figure 1

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