Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

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Pearson Edexcel International A Level
In Pure Mathematics (WMA14) Paper 01

General

This paper had many accessible questions, and it was pleasing to see candidates were able to make attempts at all of the questions, even if not all parts were attempted. There were many familiar types of questions, so candidates should have felt prepared had they completed past papers. There were some questions which candidates found particularly challenging, namely Questions 5, 9 and 10. There were a lot of blank responses for 10(b), but this was likely to be as a result of the level of difficulty, rather than not having enough time to complete the paper. The paper provided good discrimination across all candidates and all abilities should have been able to demonstrate what they could do. It should be noted, however, that there are the warnings at the start of some questions stressing the importance of showing all stages of working, as well as the rubric at the front of the paper stating that sufficient working should be shown. Some candidates still do not provide evidence of a full method, which may result in not being awarded all of the available marks.

Report on individual questions

Question 1

This was a standard binomial expansion question and was accessible to most candidates with many securing full marks. There were very few candidates who did not know where to start. Part (a) was generally answered more successfully than part (b).

In part (a), the requirement was to find the first four terms of the expansion of $(8-3x)^{-\frac{1}{3}}$.

Most candidates recognised the need to take out a factor of $\frac{1}{2}$, however some candidates failed to take any factor at all, some used a factor of 2 or less commonly 8. When applying the binomial expansion, nearly all candidates had the correct structure for the third or the fourth term. Some candidates did not obtain $\frac{3}{8}x$, often using x or $3x$; where this was the case, they did not score any accuracy marks. There were some sign errors and arithmetical slips when evaluating the terms and some candidates made slips when multiplying their expansion by $\frac{1}{2}$.

In part (b), candidates were generally less successful, but most attempted it, and many scored full marks. Candidates generally recognised the need to substitute $\frac{2}{3}$ into their expansion from part (a), however many incorrectly assumed that this would give them the required $\sqrt[3]{6}$. Candidates need to be aware that it is important to substitute x into the original expression to determine what their expansion is approximating. In this case, the expansion approximated the reciprocal of what they were asked to find. A further point to note was that while the question requested a rational answer, many candidates gave a decimal answer.

Question 2

This question assessing proof by contradiction, simultaneous equations and quadratic equations proved to be quite challenging and differentiated well between candidates of all abilities.

The vast majority of candidates attempted the question. However, a significant minority failed to recognise the need to set up proof by contradiction formally, omitting the required assumption stage and as a result failed to score the first mark. Many such candidates went straight into trying to solve the simultaneous equations. This mark was independent of the rest of their work, so these candidates were still able to score 3 marks out of 4.

The question demanded that candidates used algebra in their proof and had the common bold calculator warning that candidates should now be very familiar with. Despite the inclusion of these warnings, a significant proportion of candidates failed to show any method for solving the resulting quartic equation $\left(x^4 + 8x^2 + 15 = 0\right)$, or an equivalent quadratic equation, forfeiting the method mark and hence the following two accuracy marks. Many of these candidates used their calculators to solve the equations with the values -3 and -5 or $3i$ and $5i$ appearing without justification. A small number tried to use the discriminant on the quartic and failed to recognise that this in fact provided solutions for x^2 and hence had not helped them make progress with the proof.

For those that made some progress with the question, the most common approach was in trying to solve the equation and the correct values were found by many candidates using an algebraic method. Common alternatives included trying to argue that $x^2 \ldots 0$ and $x^4 \ldots 0$ and there were many variations on these. These approaches were harder to argue and typically candidates lost accuracy marks due to insufficient justification, or for inaccurate work which often included the incorrect use of strict inequalities, i.e., $x^2 > 0$.

The conclusion was often poorly attempted or omitted, with very few candidates referring to the fact that there were no real roots or stating for example that $\left(x^2+3\right)$ cannot be zero without any justification.

There were, however, many excellent attempts using all approaches, and as such this question proved effective at distinguishing the best candidates from the rest of the cohort.

<u>Question 3</u>

For many candidates this was quite a straightforward question, with 8 or 9 marks frequently gained.

Part (a) was usually well done, but some candidates were unable to differentiate *x* correctly, sometimes changing it into a more complex expression. There were fewer errors in differentiating *y*.

The majority of candidates realised that they needed to divide $\frac{\mathrm{d}y}{\mathrm{d}\theta}$ by $\frac{\mathrm{d}x}{\mathrm{d}\theta}$ to find $\frac{\mathrm{d}y}{\mathrm{d}x}$, scoring at least the method mark here.

Part (b) was also well done, since those who made mistakes in part (a) were usually able to score method marks. A few candidates, however, found the equation of a normal or did not give the equation in the requested form.

In part (c) many candidates were able to manipulate the given equations successfully to achieve the given Cartesian equation, though some solutions were long and complicated. Relatively few responses simply showed that both $8x^2$ and $9(2-y)^3$ were equal to $72\sin^6\theta$. It was very common for the value of *k* to be omitted, although most answers, if seen, were correct.

Candidates should be encouraged to read the demands of the question carefully before moving on.

Question 4

This was a well answered question in general testing implicit differentiation and exponentials and logarithms.

Most candidates achieved part (a) by substituting both values in and achieving 0. A minority of candidates used the *x* coordinate to find the *y* coordinate. Though not required on this occasion, only a small proportion wrote a conclusion which was disappointing for a verify question.

Part (b) was well understood as implicit differentiation and most proceeded through a correct method. The major issue for this question was poor attempts at differentiating 8^x. Most candidates who answered this correctly stated the derivative without using exponentials, though this was seen on several occasions. A common incorrect response was $8^x \times \ln x$. Other errors that occurred in this question generally came from differentiating using the product rule as some candidates made a sign error. When rearranging, the common mistake was making a sign error when changing sides. It was good to see that very few candidates wrote $\frac{\mathrm{d}y}{\mathrm{d}x} =$ at the start and ended up with the extra $\frac{\mathrm{d}y}{\mathrm{d}x}$. The common error made on multiple responses was not differentiating the constant to get 0 and instead leaving it unchanged.

Part (c) was again well understood and most who had a correct (b) proceeded to a correct answer to (c). However a minority of candidates did struggle with the rearranging and changing the ln8 into an expression with ln2. Most used the mark scheme method, but some candidates did use $y = mx + c$ to set up the equation, found c and then substituted in $y = 0$. This was generally well answered, though not as efficient an approach.

Question 5

This was the first question on the paper where large numbers of candidates struggled. Some scored only one mark, for finding $\frac{dV}{dh}$ in part (b).

Part (a) was often not attempted, but those who were able to use the similar triangle ratio to link r and h generally went on to gain both marks. Some candidates were completely confused as to what to do and just substituted in 12 and 30 into the formula for the volume. Occasionally some candidates just proceeded to substituting in $r = \frac{2}{5}h$ without clearly showing the link in earlier work. In these cases, candidates were unable to score the marks because there was insufficient of evidence to demonstrate they had not just worked backwards from the given answer and did not understand where the link between r and h had come from using the 12 and 30.

The first mark in part (b) was scored by large numbers of candidates, but was often followed by working which gained no further marks. There was frequently no attempt to find the value of h, while a common error was to use 1.5 or 90 (the time in minutes or seconds) as a value for h. Sometimes, when h was correctly attempted and evaluated, there was no attempt to use the chain rule to find $\frac{dh}{dt}$. Algebraic and arithmetic errors, particularly in dealing with reciprocals, were also frequently seen.

Question 6

This question testing the substitution method for integration was attempted by most candidates. Answers to this question were generally correct methods though a fair number struggled to begin as they could not eliminate the x variable.

The derivate of the substitution had errors with many forgetting to apply the chain rule and multiply by the derivative of the bracket. When candidates achieved the third mark they were able to integrate correct and substitute the x variable back in correctly. Factorising into the correct form caused difficulties in some cases with -5 in place of -2 a common incorrect answer from poor factorisation. The majority of candidates used the substitution to find $\frac{\mathrm{d}u}{\mathrm{d}x}$ whilst some candidates used $x=(u^2-1)^{\frac{1}{3}}$ to find $\frac{\mathrm{d}x}{\mathrm{d}u}$. It was fairly common for answers that proceeded to the correct answer to have poor notation with du often omitted and on occasion the integral sign omitted. The $+c$ was remembered however by the vast majority of candidates.

Question 7

This question on the topic of volumes of revolution was generally attempted well with most demonstrating a pleasing understanding of the method required. However, it was not uncommon for candidates to make errors when squaring their expression which simplified the question and lost marks.

Part (a) was attempted successfully by the majority of candidates with algebraic division being the preferred method. Some used partial fractions. A large majority of the candidates obtained the correct values of $A=3$ and $B=7$. There was the occasional slip leading to, for example $B=7$ or 5. Surprisingly, many candidates did not simplify "$+-$" to "$-$", although this was condoned for full marks. Most wrote the answer in the required form, but those that did not (giving only the values of A and B) usually picked up the A1 in part (b) when replacing y with the correct expression in the integrand.

Part (b) was attempted by most candidates, but often less successfully. A significant number of candidates did not attempt to square y (sometimes despite quoting the correct volume of revolution formula) and therefore they were limited to only the second method mark, for integrating one of the fractional terms, in this case to a natural log. Those candidates who did attempt to square went on with varying degrees of success. A common error with squaring was to only square each of the terms in the expression, meaning they were limited to only the second method mark as they had only one fractional term to attempt to integrate, which was usually completed successfully.

Those candidates who obtained a three-term expression from squaring y were able to access all available marks for part (b). Often the accuracy marks were lost if their coefficients were incorrect, e.g. if the cross term was wrongly calculated. There were some incorrect attempts at integration, for example integrating $(x+2)^{-2}$ as $\ln(x+2)^2$. Sometimes the brackets were multiplied out, giving $\frac{1}{x^2+4x+4}$ and then the attempt to integrate often gave $\ln(x^2+4x+4)$.

After integration, bracketing was often poor, with terms such as $\ln x+2$, although the intention was usually made clear when the limits were substituted. For the candidates who got as far as having an expression of the required form, the final two marks were usually straightforward. In general, the log terms were handled well by the candidates who got this far, but there were some errors working towards the final answer after substituting the limits into a correct integration. Occasionally the final A mark was lost by candidates who mis-handled the log terms or who made slips with their substitution. For example, some candidates gave a final answer involving $\ln\frac{1}{2}$ rather than ln 2, losing the final A mark. However, the final two marks were generally achieved by those candidates who understood how to manipulate logs. Very few candidates forgot to include π in the final answer, although a fairly common slip was the use of 2π instead of π as a part of the area formula. The alternative method using substitution was rarely seen.

Question 8

This was an accessible question, and the majority of candidates were able to attempt all parts. However, only the more proficient candidates were able to achieve full marks. While most candidates demonstrated a basic understanding and made reasonable attempts, only those with a deeper grasp of the material were able to navigate the problem with sufficient accuracy and attention to detail to secure all available marks.

In part (a), the majority of candidates demonstrated a solid understanding of how to find the direction vector. However, a few candidates made arithmetic or sign errors, leading to incorrect results. Additionally, many candidates failed to include the correct notation for the vector equation of the line, specifically omitting the expression $r=$. This omission resulted in the loss of the accuracy mark, as the full vector equation of the line, which should have been written as $r=r_0+tv$, was not provided in the required form.

In part (b), many candidates provided good answers, demonstrating a solid understanding of the question. However, a number of candidates did not correctly use the coordinates of point *B*, opting instead to equate the lines directly. This approach often led to equations that were too complex to solve, resulting in incomplete solutions and not enough progress to achieve even the first method mark. Where candidates did set up and solve the more efficient equations, the majority achieved full marks with sign errors generally being the reason for the lost accuracy.

In part (c), candidates generally answered well, with many demonstrating a solid understanding of the concept. However, a surprising number of candidates did not correctly apply the scalar (dot) product, mistakenly using points rather than direction vectors. As this was an incorrect approach, these candidates were unable to earn any marks for their solutions.

Of those who correctly applied the scalar product, a small minority lost marks for not recognizing that the negative value of $\cos\theta$ indicates an obtuse angle. It is encouraged that candidates are taught to correctly interpret the result of the dot product and understand its geometric implications, such as identifying when the angle between vectors is greater than 90 degrees.

Part (d) was the most challenging, with a significant number of candidates leaving it blank. Among those who did attempt the question, the majority opted for the much less efficient alternative method, which, while not incorrect, was unnecessarily complicated. As a result, many candidates were unable to complete the solution successfully. Despite making good progress with earlier steps, several candidates gave up before reaching the final step of finding the length of *AC*, leading to no marks for the final part. Additionally, some candidates lost marks earlier in their solution by incorrectly using a general point *C* in the dot product, rather than $\overrightarrow{AC}$, which was required. Of the few succinct solutions seen, the majority included a well-drawn diagram, which is highly recommended for visualising geometric problems and simplifying the solution process.

Question 9

This was as accessible question to all but also differentiated between the abilities of the candidates.

Most candidates were able to access part (a) and demonstrated a good understanding of partial fractions. Occasionally, a candidate only gave the values for A and B, but they were still able to pick up the accuracy mark if their fraction was seen or used in part (b). There were a few instances of sign errors or misreads which lost the candidate the possibility of full marks in (b).

Part (b) was more challenging but was attempted by most candidates. The vast majority recognised that separation of variables was required, however a small proportion of candidates tried to apply the natural logarithm to the whole fraction upon integrating. Correct notation was generally used, the occasional integral signs, dh and dt, were missing, although this did not affect the marks awarded in this question, provided the intention to integrate was seen. Generally, a good attempt was made at the integrations with the majority of candidates recognising the need to use part (a) to integrate the terms in h. Most obtained the two natural logarithm terms and then combined them correctly to obtain a single natural logarithm term. The term in cosine was generally integrated correctly and most candidates remembered to include the constant of integration. Those who forgot the + c could not gain any more marks in this section. Common errors seen included sign errors and not dealing with the coefficient of $\frac{2}{2h-1}$ or $\frac{t}{10}$ correctly when integrating.

Most candidates found the value of the constant of integration using the boundary conditions and the majority opted to do so before rearranging to make h the subject or combining the natural logarithm terms. The method mark was available to those who either had an incorrect integration or stated $t=0$ and $h=2.5$ but then achieved an incorrect value of c having manipulated their algebra incorrectly. Rearranging the equation to make h the subject proved tricky and messy for some with sign errors, losing coefficients of their c term or not combining their c value correctly with the exponential; for others, this was very straightforward but then they lacked enough workings to gain the method and accuracy marks available given that this was a ‘show that’ question. Few candidates thought the point of the question was to just find the value of k and did not go on to rearrange their equation to make h the subject. However, there were many candidates who could use correct algebra to show h in the form given.

Part (c) was discerning with not many candidates achieving a correct answer. Many connected the question to finding a maximum of sine or cosine but did not know how to relate this to the equation in h given that sine was a term in the denominator and part of an exponential. The most common error seen was to solve $\sin\left(\frac{t}{10}\right)=0$ or -1. A few candidates attempted to use the given differential equation and proceeded with $\cos\left(\frac{t}{10}\right)=0$ to find a value for 't'; this gained no marks as the question stated 'Hence find ….' indicating that part (b) should be used. Occasionally degrees were used which gained no marks.

<u>Question 10</u>

This question proved very challenging for many candidates to access. There were a lot of blank responses. Part (a) was attempted more successfully than part (b).

Some candidates were unable to proceed from $\int y\,\mathrm{d}x$ to $\int y\frac{\mathrm{d}x}{\mathrm{d}t}\mathrm{d}t$ and chose instead simply to replace dx by dt. However, candidates who had a good understanding of parametric integration could access all three marks in part (a) easily. Nearly all candidates understood the need to use the sine double angle formula, although there were some who did not seem to recognise this, often ending up with a multiplying factor of 6 rather than 12. Those who did not obtain full marks in part (a) often picked up the B1 for $\frac{\mathrm{d}x}{\mathrm{d}t}$ and/or the M1 for using a correct expression for $\sin 2t$ within their expression for y (seen on its own or within the integrand). If B1M1 was scored it was usually easy for candidates to obtain the final mark, too. Occasionally candidates lost the dt or the limits on the final answer, but this was surprisingly rare. Other errors seen included:

- some candidates misunderstood the requirements and expressed y in terms of x;
- the volume formula rather than the area formula was applied at times;

- some attempted to find $\frac{dy}{dx}$.

Part (b) was often left unattempted. When it was attempted, only a small proportion of candidates used integration by parts correctly to obtain the first M1. Often then the candidates did not know how to integrate powers of trigonemtric functions. A common mistake was to integrate $\sin^3 t$ to $\sin^4 t$. So, scoring only the first M1 was a common mark profile for those that attempted it. For those who were able to access the second M mark, by replacing $\sin^2 t$ with $1-\cos^2 t$, to reach an integrable form, the rest of the marks became accessible. But not many candidates got this far. Other mistakes seen included:

- doing integration by parts the wrong way round;
- not attempting integration by parts, but trying to use a trigonometric identity to change the integrand, and then making no further progress. Most commonly this involved $\sin^2 t = \frac{1}{2} - \frac{1}{2}\cos 2t$ or $\sin^2 t = 1 - \cos^2 t$;
- integrating incorrectly, e.g. treating the product as though it was a sum and integrating each part of it separately;
- sign errors were often introduced, for example by integrating $\cos t$ to $-\sin t$, leading to the loss of the A marks.

There were also many alternative approaches. Two alternative methods were detailed on the mark scheme and the substitution $u = \sin t$ was seen in some responses, although rarely leading to a fully correct solution. Some of these alternative attempts involved:

- other ways to attempt integration by parts;
- use of the trigonometry factor formulae;
- unusual substitutions.

While many substitutions resulted in expressions that were not integrable, all of these unusual responses required careful consideration to determine whether marks were warranted.