Examiners' Report
Principal Examiner Feedback

January 2025

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

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General Comments

This paper proved to be a good test of candidates' ability on the WMA14 content and plenty of opportunity was provided for them to demonstrate what they had learnt. Marks were available to candidates of all abilities

In general presentation was very good. The candidates often showed all the work required using appropriate mathematical notation. However, some candidates demonstrated an over-reliance on calculators. This was particularly true in question 9(b), where answers sometimes appeared with no working despite the warnings in the question to 'show all stages of your working' and 'not to rely entirely on calculator technology'.

The questions that candidates found hardest were the ones that required candidates to apply their knowledge in an unfamiliar context. Question 3 on binomial expansions was presented slightly differently and there were frequent arithmetic and/or algebraic errors. Question 8(d) was also found challenging with many candidates not able to establish a suitable strategy and often scoring no marks.

Question 1

This was an accessible opening question with almost all candidates knowing how to find a volume of revolution about the *x*-axis and many being able to integrate $\left(\frac{4}{x+2}\right)^2$, substitute limits correctly and reach the correct answer. There were comparatively few errors, and it was rare for candidates to make no attempt at this question. Pleasingly, answers were generally left in terms of π, although, unsurprisingly, some solutions had π omitted from the start.

Where errors were seen, they included:

- Not squaring the 4 in the numerator (or thinking that $4^2 = 8$), or finding the integral of y

- Expanding the denominator and then incorrectly applying logs to reach $\dfrac{16\ln\left|x^2+4x+4\right|}{2x+4}+c$
- Incorrectly splitting the denominator into separate terms, so that they obtained $\displaystyle\int_0^8\left(\frac{16}{x^2}+\frac{4}{x}+4\right)\mathrm{d}x=\left[-\frac{16}{x}+4\ln x+4x\right]_0^8$ which was not defined for $x = 0$, so they could not have the method mark for substitution of the limits

Question 2

Overall, this question appeared to be accessible to the majority of candidates with very few blank scripts seen. Responses appeared to be generally well presented indicating a confident approach to implicit differentiation with the majority of dropped marks being lost through slips or basic errors.

In part (a), the differentiation of 2^x proved to be the most challenging. A high proportion of candidates clearly knew the result and were able to write down the derivative correctly, others derived it from first principles and $\mathrm{e}^{x\ln 2}$ was seen fairly frequently. Some candidates however, mistakenly combined coefficient and base to give 20^x and although this was sometimes followed by a correct differentiation of 20^x it was not awarded any credit. Others tried to apply the product rule to $10\left(2^x\right)$ but failed to recognise that 10 should differentiate to 0. Other errors included incorrectly differentiating 2^x to give $x2^{x-1}$ or $x\ln 2$ or, in some cases, simply leaving the term unchanged by the differentiation process. Rather too many candidates retained the + 35 in the derivative, a basic error which was perhaps more likely to have been an oversight rather than a belief that 35 should be retained. On the left-hand side, perhaps surprisingly, the use of the chain rule in the differentiation of $5y^2$ proved to be more challenging than the application of the product rule in the differentiation of $4x^2y$ and $5y\dfrac{\mathrm{d}y}{\mathrm{d}x}$ or $10\dfrac{\mathrm{d}y}{\mathrm{d}x}$ were commonly seen errors. Factorising out $\dfrac{\mathrm{d}y}{\mathrm{d}x}$ was generally handled with confidence, although sign slips sometimes occurred here and occasionally the term in y was lost. A small number of candidates divided the equation through by a factor of 10 initially which was, of course, acceptable. It was very rare to see a spurious $\frac{\mathrm{d}y}{\mathrm{d}x}$ included on the left-hand side of the derivative and rarer still to see it incorporated into the final result.

Part (b) was left blank by a minority of candidates. Of those who attempted this part, most realised that $\frac{\mathrm{d}y}{\mathrm{d}x}$ was the gradient and understood that they first needed to find the value of y at P. In most of these cases, candidates worked accurately but were sometimes limited to one mark out of two if there had been earlier errors in their expression for $\frac{\mathrm{d}y}{\mathrm{d}x}$. Perhaps surprisingly, a common error was to forget to take the square root when finding the value for y, so $y = 9$ was not uncommon. Unfortunately, some candidates had managed, in part (a), to lose the y term on the denominator of $\frac{\mathrm{d}y}{\mathrm{d}x}$ and as a result had no reason to find a value for y. This unfortunately meant they lost the method mark here. There were clearly some candidates who evaluated $2^0 = 0$ or $2^0 = 2$. A significant basic error which lost the accuracy mark. The majority of candidates noted $y > 0$ so rejected $y = -3$. Only a couple of examples were seen where gradients were found for both values of y. There was a small minority of candidates who incorrectly set the numerator of $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ and so could make no further valid progress.

Question 3

Overall this question was well answered by candidates, particularly parts (a) and (c).

In part (a) the majority were able to correctly factor out $4^{-\frac{1}{2}}$. Those that had a problem here mainly either factored out $\sqrt{4}$ to give 12 or simply left the first term as 6. Most candidates were able to gain at least the method mark for finding the value of A. The second method mark, for finding the value C, was lost by some candidates as they forgot to square the coefficient of x^2. A common error for those who lost the accuracy marks for this question was to forget to include the multiplier 3, especially with the second accuracy mark, possible due to the 3 already included in the calculation, as many then went on to correctly include the multiplier 3 in part (c).

In part (b), a significant number of candidates were not able to find the range of values of x for which expansion was valid. For those that had a good idea of how to approach part (b), many lost marks by either not rearranging their $\frac{A}{4}$ or in doing so, failed to state a correct range e.g. $x < 6$ instead of $|x| < 6$. The vast majority of candidates with a correct answer used a strict inequality.

Part (c) was often answered well, with a similar pattern to finding the value of C from part (a), except more candidates remembered to include the "3" this time. Again, a number of marks were lost by not cubing the coefficient of x^3. A number of candidates benefitted from the correct x^3 being allowed rather than just the coefficient.

The majority of marks lost by candidates in this question were due to poor processing rather than a lack of understanding. In particular, many candidates missed out on marks they were capable of gaining due to poorly structured working.

Question 4

Overall this question was answered well with a high proportion of candidates attaining full marks.

In part (i), most candidates attained the first two marks, realising that $\frac{\mathrm{d}V}{\mathrm{d}t} = 70\pi$ and correctly differentiating V to get $\frac{\mathrm{d}V}{\mathrm{d}r} = 4\pi r^2$. There then followed a correct application of the chain rule to find $\frac{\mathrm{d}r}{\mathrm{d}t}$ when $r = 5$. A significant minority correctly obtained an expression for $\frac{\mathrm{d}V}{\mathrm{d}t}$ in terms of r but then failed to substitute 5 for the radius, losing both the method and accuracy marks.

There were a few attempts to find r as a function of t by first integrating $\frac{\mathrm{d}V}{\mathrm{d}t}$ to find V and then using the formula for the volume of a sphere. Units were not required in the answer, but it was necessary for any units that were given to be correct to obtain the final accuracy mark.

In part (ii), the majority of candidates recognised this as requiring a separation of variables approach. The most successful method was to leave the constant k on the right hand side and to integrate both sides. A minority omitted a constant of integration at this stage and thus lost all of the remaining marks in this part. Most attempts could find the constant of integration and k correctly and then proceed to the correct value of the time required. Candidates usually rounded their answer to the required one decimal place, but some did give their answer as an improper fraction or rounded to more decimal places.

A more complicated approach started by separating the variables with k moved to the left hand side. This required more algebraic manipulation and simultaneous equations to find the constant of integration and k but candidates following this approach were usually successful.

As in part (i), units were not required in the answer, but it was necessary for any units that were given to be correct to obtain the final accuracy mark.

<u>Question 5</u>

This question provided a good source of marks for many candidates.

In part (i) most candidates successfully integrated by parts at least once, with many following up with a second integration and obtaining the correct answer. A minority who attempted to integrate by parts, chose the incorrect term to be their 'u' and obtained an expression containing x^3 terms, so getting stuck and gaining no marks. A larger number confused integration with differentiation concerning the exponential, so set $\frac{\mathrm{d}V}{\mathrm{d}x} = \mathrm{e}^{4x}$ and then $V = 4\mathrm{e}^{4x}$, getting the correct structure for the answer but incorrect constants, typically gaining just the M marks. A significant number just made a sign error with the third term, failing to appreciate the double minus, so gaining 3 marks. A small minority of candidates used the D&I method, almost always successfully. Only a few candidates failed to realise integration by parts was needed and so made no progress.

In part (ii), almost all candidates found the correct partial fractions, with just a few making a numerical slip. Almost all candidates knew that the fractions needed to be integrated to a logarithmic form. Some, however, did not achieve the correct coefficients, typically forgetting to divide the first term by 2 and the second term by −1 so losing the A mark. Most candidates then applied the correct limits to their integral. A majority used brackets rather than modulus signs, but most seemed aware that eg ln(–2) should be corrected to ln2, with just a small minority making terms such as ln(−2) disappear. A significant number of candidates failed to manipulate their 4 ln terms correctly to reach the final answer, either reaching a single incorrect value or giving up and leaving their answer as 2 or 4 ln terms. Only a few candidates attempted the integration without using partial fractions and so failed to make any progress.

Question 6

This question was a good discriminator between candidates. As is often the case for questions on proof there were a notable number of blank scripts, although this appeared to be less commonly seen than in previous sessions.

The vast majority of candidates, though, were clearly well-prepared and were able to demonstrate a strong understanding of how to construct a robust proof, were clear in their assumptions and chains of reasoning to lead to clear contradictions. The most successful responses began by considering the even case for n by setting, for example $n = 2k$ and proceeded successfully to $4k^2 - 8k + 5$. Poor algebra such as faulty factorising or sign errors was sometimes responsible for loss of either or both of the final A marks, but a significant number of candidates succinctly rearranged to establish an odd format and concluded clearly. Common approaches included rearranging to e.g. $4(k^2 - 2k + 1) + 1$, or completing the square to give $(2k - 2)^2 + 1$ and a relatively small number of candidates divided each term by 2, arguing that the result was non-integer. Some candidates also considered the odd case for k which was ignored. A significant number of scripts included only minimal or almost no algebra, instead relying on logical arguments based on the consideration of individual terms to build a picture of overall parity of the expression. Other candidates began instead by setting $n^2 - 4n + 5 = 2k$

and usually this approach was less successful because the reasoning that followed was often incomplete and included statements that were not fully justified such as "$n(n-4)$ odd => n odd".

Less successful candidates were usually those who were unclear on the structure required of a proof of this type. Despite being instructed to prove by contradiction, the initial statement of assumption was omitted in a surprising number of cases. Some candidates struggled with the wording of the assumption in respect of whether they should be using odd or even for both or either element. Other candidates despite algebraically reaching an 'odd form' failed to make a statement that their result was odd. The usually common error of setting, for example, $n = 2n$ was seen perhaps in fewer cases than in previous sessions and poor attempts which considered individual numerical examples for n were also fairly rare.

Question 7

Many candidates who followed the instruction to use the substitution $x = 4\sin\theta$ were successful and progressed to earn the full 6 marks. They stated $\frac{\mathrm{d}x}{\mathrm{d}\theta} = 4\cos\theta$, worked out the new limits for θ, applied $1-\sin^2\theta = \cos^2\theta$ to simplify the denominator to $64\cos^3\theta$, which reduced the integral to $\int \frac{1}{16\cos^2\theta}\,\mathrm{d}\theta$. Some then did not know how to proceed and thought further identities were needed. Those who recognized the requirement to integrate $\sec^2\theta$ were often able to complete successfully. Quite a few candidates were unable to complete the crucial step of simplifying $\left(1-\sin^2\theta\right)^{\frac{3}{2}}$ to $\cos^3\theta$. A significant number also failed to progress beyond the initial substitution and a few candidates failed to attempt the question. Some solutions were seen with angles expressed in degrees. Though this was condoned, it should be discouraged, particularly as the common calculus trigonometric results rely on use of radians.

Those candidates who were not fully successful sometimes made an arithmetical or sign error but still scored well. Common slips were taking out a factor of 16 in the denominator but not applying the index $\frac{3}{2}$, or taking the factor of 4 in the numerator outside the integration sign but then forgetting it.

For those who correctly applied the substitution to reach a correct simplified form, there were various incorrect attempts to integrate such as:

$$\int \frac{1}{\cos^2\theta}\,\mathrm{d}\theta = -\cos^{-1}\theta + c \text{ or } \int \frac{1}{\cos^2\theta}\,\mathrm{d}\theta = \ln\left|\frac{\cos^2\theta}{-2\sin\theta\cos\theta}\right| + c$$

In some cases, the candidates were still able to earn the third method mark for substituting the correct limits for θ and subtracting the right way round. A small number of candidates made an error with the indices resulting in $\int \sec\theta\,\mathrm{d}\theta = \ln|\sec\theta + \tan\theta| + c$ and in these cases, candidates could also earn the third method mark. The candidates who ignored the instruction to use the substitution $x = 4\sin\theta$ tended to make no progress at all.

Examples of their approaches included:

$$\int (16-x^2)^{-\frac{3}{2}}\,\mathrm{d}\theta = -2x(16-x^2)^{-\frac{1}{2}} + c \text{ or } \int (16-x^2)^{-\frac{3}{2}}\,\mathrm{d}\theta = \int\left(\frac{1}{64} - x^{-3}\right)\mathrm{d}x = \frac{1}{64}x + \frac{1}{2}x^{-2} + c$$

Question 8

The majority of students found part (a) accessible and scored both marks although there were some arithmetic errors. Some students started well but quoted the values of lambda rather than continuing to find *a* and *b*. Some found a value of lambda associated with *a* and mistakenly used this to find *b* rather than finding a second value of lambda.

In part (b), most used an appropriate method to find vector *AB* and presented it with correct notation. The majority of those failing to score full marks did so due to using incorrect values of *a* and/or *b* within their vectors, however the method mark was still available to them. Processing errors seemed rare but some did fail to subtract a negative value correctly. A minority attempted the incorrect method of adding vectors *OA* and *OB*.

The majority of students selected an appropriate method in part (c) and clearly showed their working. Working with the scalar product was the most favoured method although the cosine rule was also seen. On the whole, correct vectors were selected for their chosen method but some students incorrectly calculated and used vector *BC* rather than *AB* in their scalar product and some used *OC* rather than *AC*. Students should be encouraged to draw a sketch as this could reduce this type of mistake. Most were able to correctly find the scalar product but there were some errors with negative signs, however, method marks could be awarded if the intention was clear. Unfortunately, some students stated incorrect values without working which meant they could not be credited for demonstrating the correct method to find the required angle. Some students found the obtuse angle, however most correctly converted this to the desired acute angle. It was rare to see an angle presented in radians as the majority gave the result in degrees to one decimal place as required.

Part (d) was more challenging for students with many not attempting a solution. Students should consider sketching a diagram as this can clarify their thought process and perhaps save unnecessary working. It appeared that those who could visualise the scenario were able to select an appropriate value for lambda and successfully find at least one position for *D*. The most successful students chose the easier method of adding or subtracting $2\times AB$ to *OA*.

Those who went down a route with area calculations often failed to progress far enough to gain any credit but those who persevered produced some thorough calculations showing a great deal of precision. However, some students chose to work with rounded decimals rather than exact surds which compromised their accuracy. It should be emphasised to students that rounded decimal values are only approximations. Answers were often given as vectors and not as coordinates.

Question 9

There were some instances of non-response for this question.

In (a)(i), the vast majority of candidates correctly found $\frac{\mathrm{d}x}{\mathrm{d}t}$ but many found $\frac{\mathrm{d}y}{\mathrm{d}t}$ more difficult to derive. Some candidates wrote it as $\sin t \sin^2 t$ and then used the chain and product rules rather than applying the chain rule to the original function. Those who did attempt to find $\frac{\mathrm{d}y}{\mathrm{d}t}$ and $\frac{\mathrm{d}x}{\mathrm{d}t}$ combined these correctly to find $\frac{\mathrm{d}y}{\mathrm{d}x}$. Candidates who obtained a correct form for $\frac{\mathrm{d}y}{\mathrm{d}x}$

were generally able to use the double angle formula to simplify the expression to the required form but a significant minority omitted the 2 from $2\sin t\cos t$.

In (a)(ii) candidates were more successful, with many finding the *x* and *y* coordinates correctly and then used their gradient from (i) to find the equation of the tangent. Very few used the normal gradient. Some candidates used the given answer to adjust their answer to part (i) in order to obtain the correct gradient for this part. Unless they fully corrected part (i), they were unable to score the final mark on this part. A minority of candidates stated that the gradient was their *k* from part (i).

In (b), most candidates substituted the parametric expressions for *x* and *y* into the given tangent equation and then used trigonometric identities to form a cubic sine equation. A minority used an incorrect identity. The cubic equation could be solved using a calculator but quite a number of candidates used algebra to get the quadratic equation and then solved it by factorising. Finding the coordinates of *Q* was well done by those who managed to solve the cubic equation though some made a sign error on the *y* coordinate. A few candidates tried to eliminate *t* and produce a cubic equation in either *x* or *y*. The algebra required for this method was more challenging and so candidates often made errors on rearranging. There were particular instances in part (b) where candidates reached an equation they were unable to solve analytically and so reverted to a numerical approach using a calculator. Such responses generally did not score full marks.

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