Examiners' Report

Principal Examiner Feedback

October 2021

Pearson Edexcel International A Level

In Pure Mathematics 4 (WMA14)

Paper: WMA14 / 01

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October 2021
Publications Code WMA14_01_ER_2110

General

This was a fairly standard WMA14 paper. There were plenty of very accessible early questions, with many of the later questions written to test the best of candidates. It was noted that there were many more blank attempts at questions this series, especially in question 7 and 9. Generally the standard of algebra was sound. Presentation should, and could be greatly improved, not only in the setting out of a proof, but also in making clear all numbers and words in written solutions.

Report on individual questions

Question 1

This proved to be a good introduction to the paper for a prepared candidate, and a pleasing number gained full marks.
The first three marks could be gained for correctly differentiating the given equation. For candidates who knew the basic technique, common errors seen included

- differentiating $3x^2y \to 6x\frac{\mathrm{d}y}{\mathrm{d}x}$
- differentiating $4y^2 \to 8\frac{\mathrm{d}y}{\mathrm{d}x}$
- and surprisingly differentiating $4x^2+8 \to 8x+8$

Once a candidate had differentiated correctly and achieved the two $\frac{\mathrm{d}y}{\mathrm{d}x}$ terms, many could then go on to score all 7 marks. Reasons for dropped marks later on in the solution were as a result of arithmetic/ algebraic errors as well as a few cases in which a tangent rather than a normal equation was found. Very few marks were lost this series for leaving the answer in an incorrect form, that is in this case $y = mx + c$, or omitting the = 0 in the equation $11x - 14y - 5 = 0$.

Question 2

The second question, on first order differential equations, proved more demanding than the first. Many candidates who decided to "move" the 4, ended up with an incorrect starting equation of $\int \frac{4}{y^2}\mathrm{d}y = \int \frac{1}{\sqrt{4x+5}}\mathrm{d}x$ at some point. Most candidates knew how to integrate at least one of the sides although common incorrect solutions included terms such as $\ln(y^2)$ or $\left(4x+5\right)^{\frac{3}{2}}$. The majority of prepared candidates could integrate both sides correctly and only made slips on the coefficients of the terms. Many could then go on to obtain a constant and change the subject using a correct method to find y as a function of x, as requested. It was pleasing to see relatively few cases in which an equation of the form $\frac{a}{y} = b\sqrt{4x+5}+c$ was incorrectly changed to

$$\frac{y}{a} = \frac{1}{b\sqrt{4x+5}} + \frac{1}{c}$$

Question 3

The majority of candidates were able to achieve good marks on parts a and b of this question. Part c was found to be very demanding and many struggled to give a complete explanation as to why $g'(x) > 3$.

In part (a) the main methods used to find the constants were from an identity, or else by long division. Those who used the right identity usually went on to get all four correct values without any real issues. Those using the long division method usually achieved the correct linear quotient, scoring 3 marks, but struggled to use the remainder to find values for *C* and *D*. The most common error with candidates who used this method was to set the numerator of the partial fraction equal to 6 rather than -6 and then forgetting the negative when the values were put back into the expression. Others could not deal with the partial fractions at all.

Part b was completed reasonably well, with the majority using the right method, although some of these candidates made sign errors The most common mistake in the method was differentiating into logarithmic expressions with $-\frac{2}{x} \to -2\ln x$ and $\frac{2}{x+3} \to 2\ln\left(x+3\right)$
Most candidates decided to omit part (c). Of those that did make attempts, many stated that as $x \to \infty$, both $\frac{2}{x^2}$ and $\frac{2}{\left(x+3\right)^2} \to 0$ so $g'(x) \to 3$ meaning $g'(x) > 3$. It was important to state that, as $x > 0$, $\left(x+3\right)^2 > x^2$ meaning that $\frac{2}{\left(x+3\right)^2} < \frac{2}{x^2}$ and so $3 + \frac{2}{x^2} - \frac{2}{\left(x+3\right)^2} > 3$

Question 4

In part (a) it was surprising to see how many candidates were confused by the $4x^2$ term, with some replacing it with $4x$ whilst others attempting a more difficult $(1-2x)^{\frac{1}{2}} \times (1+2x)^{\frac{1}{2}}$. For those who did spot the simplicity of the question, most then went on to score all 4 marks in part (a) via the intermediate expression $1 + \frac{1}{2} \times \left(-4x^2\right) + \frac{\frac{1}{2} \times -\frac{1}{2} \times \left(-4x^2\right)^2}{2} + \frac{\frac{1}{2} \times -\frac{1}{2} \times -\frac{3}{2} \times \left(-4x^2\right)^3}{3!}$
An incorrect final term of $-4x^8$ was seen more times than would have been expected.

In part (b), scores of 0 marks were very common with $x = \frac{1}{4}$ being substituted into only one side of the expansion. It was important to see $x = \frac{1}{4}$ being substituted into **both** sides of the expansion to obtain $\sqrt{\frac{3}{4}} \approx 1 - 2 \times \left(\frac{1}{4}\right)^2 - 2\left(\frac{1}{4}\right)^4 - 4\left(\frac{1}{4}\right)^6$. In that way the approximation to $\sqrt{3}$ could easily be obtained .

Question 5

Most candidates who attempted part (a) did so via parametric differentiation, as demanded by the question. There were many competent and complete attempts with many reaching a correct answer. Common errors in this part included

- Incorrect attempts to differentiate $y = 8\sec^2 t$
- Solutions of $3 = 5 + 2\tan t$ resulting in $t = \frac{\pi}{4}$ rather than $t = -\frac{\pi}{4}$
- Differentiating the Cartesian equation $y = 2(x-5)^2 + 8$

In part (b), many knew that to eliminate the parameter, the equation $1 + \tan^2 t = \sec^2 t$ was required. Unfortunately even though many achieved a correct intermediate answer of $1 + \frac{(x-5)^2}{4} = \frac{y}{8}$, a sizeable minority of these could not proceed to $y = 2(x-5)^2 + 8$

Part (c)'s focus was the range of the function, and a graph was provided to help. Common incorrect solutions followed attempts to substitute either end of the domain in the parametric equation for y. This usually resulted in only one of the two marks being scored, with the minimum value missing, a value that could have easily been obtained from the 8 of $y = 2(x-5)^2 + 8$.

Question 6

This was a question that was very much centre dependent. There were lots of very well constructed and fully correct solutions yet an equal number that did not know where to start,

Of those who knew "integration via substitution", most scored the first mark for $\frac{\mathrm{d}u}{\mathrm{d}x} = 4\cos x$

Many then went on to use the substitution $\sin 2x = 2\sin x\cos x$, form an integral in just u before simplifying and integrating. The application of the changed limits of 5 and 7 was frequently scored by candidates who had failed to integrate correctly.

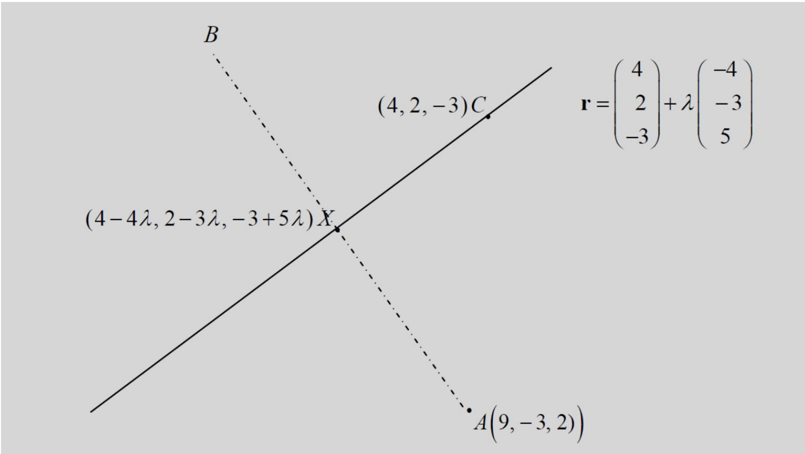
Common errors witnessed, that usually resulted in the loss of most marks were

- candidates who changed $\sin 2x$ to $\sin 2\left(\sin^{-1}\left(\frac{u-3}{4}\right)\right) = 2\left(\frac{u-3}{4}\right)$
- candidates who ignored the dx and simply wrote it as du

Some very good candidates missed out on the final mark for not writing $-\frac{12}{35} + 2\ln\frac{7}{5}$ in the form required by the question.

Question 7

This was another question where many candidates had no idea of how or where to begin. There were many blank responses as well as an equal number that scored no marks at all. Those that did manage to score marks tended to score most of them. It is worth repeating that it is good practice in a geometric question to sketch out a diagram.



In part (a) most incorrect responses attempted to set

$$\begin{pmatrix} 4-4\lambda \\ 2-3\lambda \\ -3+5\lambda \end{pmatrix} . \begin{pmatrix} -4 \\ -3 \\ 5 \end{pmatrix} = 0 \quad \text{rather than} \quad \overrightarrow{AX} . \begin{pmatrix} -4 \\ -3 \\ 5 \end{pmatrix} = 0$$

This immediately resulted in 0 marks for (a)(i). Most candidates who attempted the latter scored 4 or 5 marks.

Candidates who got an incorrect X could still pick up method marks in (a)(ii) and (b) but many gave up after part (a). Other methods were seen in part (a) including minimising the length of AX using either differentiation or by completing the square.

Question 8

Part (a) was straightforward bookwork for a prepared candidate. The application of "integration by parts" was well known and applied correctly by a great number of candidates. Surprisingly, perhaps, there were many other attempts that were blank, or showed no knowledge of the topic whatsoever.

Part (b) was very demanding and a very good discriminator at the high grades. Candidates could use their answer from part (a) after another application of "parts". Unfortunately many candidates assumed that $\left(\ln x\right)^2$ was identical to $2\ln x$ and failed to score. There were some excellent well formed solutions however, showing skill in both calculus and algebra.

Question 9

This proved to be yet another demanding question in this series. It was strange to see the number of candidates who did either part (a) or (b) successfully yet made no attempt at the other part. There were also many blank responses, probably due to a lack of familiarity of this type of question due to lockdowns.

Part (a) required candidates to write the information given in the question in terms of rates of change. There were two relatively straight-forward marks for writing down $\frac{\mathrm{d}V}{\mathrm{d}h}=16\pi$ and $\frac{\mathrm{d}V}{\mathrm{d}t}=0.6\pi-0.15\pi h$ which could then be combined and simplified to show the given statement.

Errors included

- Using the volume of the cylinder as $V=\frac{4}{3}\pi r^2 h$
- Using either $\frac{\mathrm{d}V}{\mathrm{d}t}=0.6\pi$ or $\frac{\mathrm{d}V}{\mathrm{d}t}=-0.15\pi h$

Part (b) required candidates to solve the given differential equation using the boundary condition $t=0,\ h=0.5$ to find the time before the height reached 3.5m. As with other questions there were many well constructed solutions from well prepared and able candidates. Amongst reasons for loss of marks for candidates who were able to make progress in this question were

- integrating $\frac{1}{320}$ to $\ln(320t)$
- Not using the boundary condition $t=0,\ h=0.5$ to find a value for "c" and just using $-\frac{1}{3}\ln(12-3h)=\frac{1}{320}t$ with $h=3.5$ to find t
- Giving the units for the answer 208 as seconds rather than minutes

Question 10

The first part of this question, on proof by contradiction, included a partially completed attempt at showing that if n^3 is even , then n is even. It was there to help candidates solve part (b), by not only giving them the structure of a proof, but also the key steps in helping them solve it.

A great many responses to part (a) did correctly factorise the expression, but few made a comment to state that it was odd. Both of these aspects were required to show the contradiction.

Responses to part (b) were mixed with many not understanding the meaning of a rational or irrational number. For those who did make a start and stated the contradiction

"There exists integers a and b such that $\sqrt[3]{2} = \frac{a}{b}$ "

many went on to gain two or three marks out of 5. Most of these forgot, however, to add a statement that $\frac{a}{b}$ was fully simplified which would mean that the last mark in the question could not be awarded. It is really important in a proof to include all necessary steps, and in this one it was common to see

" $\sqrt[3]{2} = \frac{a}{b} \Rightarrow 2 = \frac{a^3}{b^3} \Rightarrow a^3 = 2b^3$ " followed by "hence a is even"

rather than

" $\sqrt[3]{2} = \frac{a}{b} \Rightarrow 2 = \frac{a^3}{b^3} \Rightarrow a^3 = 2b^3$ " followed by "hence a^3 is even so a is even" (using part a)

The final part of the proof could then be reached by setting $a = 2m$, before substituting this into $a^3 = 2b^3$ to give

" $(2m)^3 = 2b^3 \Rightarrow b^3 = 4m^3$ followed by the same deduction that b^3 is even so b is even"

The order of the statements was crucial to scoring full marks, as was the fact that a and b had no common factors in the initial statement. As a result fully correct proofs were rare and only awarded to the best of candidates.

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