Examiners' Report
Principal Examiner Feedback

Summer 2022

Pearson Edexcel International Advanced Level
In Pure Mathematics P4 (WMA14) Paper 01

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The paper performed well overall except for question 9, where it is clear that candidates are not well prepared for proof questions. Questions 3, 8 and 9 had model mark of zero, though by far the greater proportion were scoring zero on question 9. All other questions had modal score of full marks.

There is evidence that the impact of Covid 19 affected overall performance with some topics weaker than anticipated possibly due to lack of teaching time. There was no evidence of timing being an issue on the paper, with most managing to attempt something on each question. There were, however, more unattempted questions than usual.

Question 1 Mean 4.61, mode 7/7 (36%)
Overall, this question performed well with most candidates able to gain marks. Only 7% scored zero. The process for finding the binomial expansion is well known, but the extraction of coefficients is less well done, and many ended up using an incorrect expression in (c) due to omission of the *A* term.

Part (a) had a mixed responses, some were able to write down *A* straight away, while others attempt to take the factor 3^{-2} out of the bracket first, sometimes then omitting it and thinking $A = 1$, or failing to sort out the power correctly, yielding 3 or 9 to $\frac{1}{3}$. Occasionally some would state the wrong value for *A* but proceed to use $A = \frac{1}{9}$ throughout the question.

Parts (a) and (b) were often merged together as candidates first instinct was to fully expand using the binomial theorem, rather than concentrate on just the information needed. Aside from the errors noted with *A* this was usually done well, with the two correct terms seen in part of an expansion. However, a common error here was to have *k* rather than $\frac{k}{3}$ and, as is common, some forgot to square the *k* in the third term. Most candidates were able to set a quadratic equation although earlier errors sometimes led to incorrect answers, or attempts to reach the given equation from incorrect work. There were many full mark response, aided by the mark scheme allowing for confusion over the terms with or without the "*A*" as part of them, since it would cancel anyway.

Most achieved the correct value of *k* in part (c) (as the quadratic was given), sometimes the only mark in the question scored. However, many found both solutions $k = 0$ and $k = -6$ and failed to reject, forfeiting the mark. Those who tried to select the appropriate solution sometimes ignored the "*k* is a non-zero constant", and instead argued that as $|kx| < 1$, *k* would have to be zero which then removed the chance to get marks in (ii).

For (c)(ii) most realised they needed to substitute the value they had found in (i) to obtain a value for the coefficient of x^3, but earlier errors often meant this was incorrect and even those who had found the value of *A* correctly commonly forgot to include it and gave 32 as the answer.

Question 2 Mean 5.41, mode 9/9 (20%)
This question proved problematic for question 2, with most scores in the range 3 - 7 marks. The second mode of 3/9 was scored by 18%, just short of the full mark mode percentage, which indicates that by and large candidate were able to obtain the partial fractions in part (a), but had much more difficult getting access into part (b).

Part (a) was a very standard partial fractions question which was well done by most candidates. Only a small minority did not attempt it and very few made numerical errors. In the majority of cases, the identity was set up correctly with substitutions made or coefficients equated without error to reach correct values for *A* and *B*. Most used substitutions of $x = -\frac{1}{3}$ and $x = 1$, the most efficient method. Errors were mostly due to incorrect calculations such as incorrect dividing to give $A = \frac{4}{3}$. A few candidates wrote $1 = A + \frac{B}{1+3x} + \frac{C}{1-x}$ but often would find $A = 0$ and so obtain the correct answer.

Part (b) was much more challenging. The separation of variables was mostly well done with only occasional cases of writing $\int \tan y \, dx = \int f(x) \, dy$ and proceeding with integration regardless. The integration of $\cot y$ was the first key point for some candidates although the scheme allowed the first method for any changed function following correct separation, meaning the incorrect integration lost only accuracy marks. There were various attempts which were usually trigonometric. Attempts at the integration of partial fractions were much more successful although there were some sign errors when processing the $1-x$ or with the position of the 3.

Most candidates remembered to include a constant of integration and were able to proceed to substitute the given conditions to evaluate it. However, many struggled to find a value due to incorrect integration of $\cot y$ leading to a function undefined at $y = \frac{\pi}{2}$, though again the mark scheme was generous in such cases. For candidates who achieved a correct integrated expression, the correct constant of integration $-\frac{1}{4}\ln 5$ or $\frac{1}{4}\ln\frac{1}{5}$ was usually found and incorporated using correct log work. However, the final method mark again proved a problem point with many not able to see how to manipulate their expression into the required form. Simply removing ln's without first combining was seen, or incorrect work to form a ln … = ln … equation was known, though many simply stopped short of reaching form required.

Question 3 Mean 3.25, mode 0/8 (28%)
This was a poorly answered question, and perhaps is a topic that has not had good coverage due to lack of teaching time because of Covid. The mode was zero marks, but 4 marks (achieved by 13%) and 6 marks (achieved by 17%) were also more common than full marks (achieved by 11%). There were a number of blank responses, with this question left out perhaps more than any other, as well as numerous weak attempts, and even good candidate were often unable to get the sign correct in part (a).

As noted, in part (a) many students failed to apply the negative sign to the given rate of decrease hence losing both the first B mark and the A mark. A notable amount also failed to identify the correct Area for the circular face, instead attempting the entire surface area. However, most who attempted the question were able to use the chain rule successfully with their value and expression to score at least the method mark.

Part (b) was overall more successful than part (a) as most students were able to identify the correct volume and differentiated it successfully to gain at least the first two marks. However, many went to use their $\frac{\mathrm{d}x}{\mathrm{d}t}$ value from part (a) and hence lose the final two marks. Those who realised the general expression (or first found the rate of change of x at $x = 4$) were often able to gain full marks in part (b) despite having dropped the two marks in (a) due to the sign error, which is why 6/8 was a common score.

Question 4 Mean 5.77 Mode 8/8 (30%)
There was much better access in this question, with as well as the mode of full marks, 6/8 (23%) and 7/8 (16%) were also common scores and less then 8% scored no marks. Implicit differentiation is an expected and familiar topic, and the function in this question was one of the more straightforward types to be given.

Part (a) was generally very well done, with the vast majority of responses fully correct. The attempt at implicit differentiation using the product rule was usually correct, but some errors were made with the signs and some bracketing errors were seen and the $\frac{\mathrm{d}y}{\mathrm{d}x}$ was sometimes connected to the wrong term. The y^3 term was less problematic. Once the differentiation was successfully achieved then the tidying up to reach the final answer was usually correct.

Part (b) proved to be more demanding for most but was nevertheless still approached well. The majority set $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ and substituted $x = \frac{5}{2}$ usually going on to achieve $15ky - 100 = 0$ though some made no further progress than the substitution. Others, after finding this equation, could not see how to proceed, not realising the coordinates also needed to satisfy the original curve equation.
In contrast there were also some students who realised the original equation was needed and produced one correct equation, but failed to use the derivative. Those who did attempt both equations usually worked through a value for *k*. Mistakes were sometimes made in making *y* or *k* or *ky* the subject but the algebra was on the whole quite good.
Other errors seen included setting $\frac{\mathrm{d}y}{\mathrm{d}x} = 1$ or losing the *k* and using $y = \frac{20}{3}$, or losing the k^3 from the $8y^3$ term and found $k = \frac{64}{27}$.

Question 5 Mean 3.87, mode 8/8 (21%) and 0/8 (20%)
Another question that proved challenging with almost as many failing to score any marks as scored full marks. Scores of 1 (13%), 2 (11%) and 6 (11%) out of 8 were also common, indicating that integration by substitution is a difficult topic for students. There were numerous blank responses, as well as many valiant, but incorrect, attempts.

Most candidates managed to achieve the B in part (a) for $p = \frac{\pi}{6}$, either by stating it in part (a) or including it as their upper limit in part (b). A small number wrote 30^0 which scored B0 in (a) but was allowed for the final A in (b) if all intermediate work was correct, however candidates would be well advised to ensure they work in radians in calculus questions.

The majority were also able to find a correct expression involving $\frac{\mathrm{d}u}{\mathrm{d}x}$ (or equivalent), though a few made a sign error (but were still able to score the method mark for this).

The second method mark was challenging, though, since a full substitution from an integral in terms of x to an integral in terms of u was not alone sufficient to access the mark, even though many did achieve a correct unsimplified integral. The requirement to also use $1 - \sin^2 u = \cos^2 u$ in the denominator made access to the mark difficult and a good discriminating mark. Those who succeeded in applying this and dealt correctly with the power $\frac{3}{2}$ were usually successful in achieving the required integral, but dealing with the power incorrect cost many the final A mark, even after a correct substitution of the Pythagorean identity.

Part (b) of the question was more accessible as candidates could rely on the formula book. Many candidates scored full marks here regardless of their efforts in part (a), with the common score of 6 achieving the four marks in (b) in most cases, though a few did lose the two accuracy marks.

There were however some who did not integrate sec u tan u correctly and ln terms appeared, perhaps from the formula book quoting the integrals of sec u and tan u separately. Very few who made any progress of note integrated the $\sec^2 u$ term incorrectly, but there were some poor attempts at integrals that bore no resemblance to the correct answer at all, so could score no marks.

As the question stated that solutions relying on calculator technology were not acceptable, candidates who did not show or imply substitution of their limits and gave the correct answer without an intermediate step were unable to score the last two marks. It is important to stress that all relevant working should be shown.

Question 6 Mean 4.92, mode 9/9 (21%)
This was a relatively straightforward vector question compared to some in recent years, yet simply by being a question on vectors was omitted by many candidates. Scores of 0/9 (18%) and 8/9 (14%) were also relatively common aside from the mode of full marks, with candidates who made an attempt usually able to gain a few marks, if not all.

Very few diagrams were seen for this question, as is common, though candidates may find sketches helpful in understanding vector questions. For the whole question, most candidates used column vectors throughout. A very small number of responses were seen where **i**, **j** and **k** were used in column vectors.

For part (a) the majority of the candidates found $\overrightarrow{AB}$ correctly. Some candidates thought that was all that was required, but many went on to write a correct expression for the line. A significant number lost the final mark as they either left the expression with no subject or as $l =$. Another relatively common error seen was finding $\overrightarrow{AB}$ correctly, but then using this as the fixed point on the line and the position vector of A or B as the direction vector.

In part (b) most responses correctly found $\overrightarrow{AC}$ and the majority of these attempted to use the scalar product. The correct answer was found by many, though there were a significant number of candidates who made careless arithmetical errors. A minority tried to find *p* by equating the **j** components rather than using the scalar product. Another common error was using the position vector of the fixed point on the line found in part (a) rather than the direction vector for the scalar product. Some simply used the position vectors of *A* and *C* for the scalar product.

Part (c) was the least successful part of the question. Candidates usually recognised that *ABC* was a right-angled triangle with the majority gaining at least one mark for finding the magnitude of one side, usually $\overrightarrow{AB}$. Those who had a correct value for *p* were frequently able to attain all of the marks, though some used $\overrightarrow{AB}$ and $\overrightarrow{BC}$ as the sides, losing two marks. Some candidates recognised that it was a right-angled triangle, but still used $\frac{1}{2}ab\sin C$, with an angle of 90°. Candidates who did not realise that it was a right-angled triangle, either abandoned the question or attempted to find an angle using the scalar product and then use $\frac{1}{2}ab\sin C$

Relatively few such attempts were completely successful, though some were able to attain two marks. Only a small amount of candidates lost the final mark by giving the area as a decimal, with most able to produce an exact answer.

Question 7 Mean 7.22, mode 12/12 (17%)
Given that parametric differentiation is an expected and familiar topic, this question proved to be more challenging that anticipated. Over 10% again either left the question out or produced no work worthy of any merit. If candidates did not know how to start, they would often not even try later parts, though a few succeeded in obtaining just the B mark in (d). Full marks was relatively rare compared with other questions though 10 (12%) and 11 (11%) marks were the next most common scores to full marks.

In part (a) the majority of candidates attempted to differentiate *x* and *y*, though a large number were unsuccessful in obtaining correct derivatives. Particularly $\frac{dx}{dt}$ was done poorly with $\cos t + 6\sin t$ being a common incorrect answer. Sign errors in coefficients were also common in both derivatives, but $\frac{dy}{dt}$ was usually correct. Most candidates attempted to find $\frac{dy}{dx}$ correctly for their derivatives, but many lost the method mark as they did not show any evidence of substitution before the given answer was stated. There were many different ways of obtaining $\frac{dy}{dx} = 3$ with incorrect expressions and candidates were thus unable to identify their own error from the construction of the question. Again an importance in showing all working is needed. However the method mark was usually scored, sometime the only mark in this part, or B0B1M1A0 was also common.

Part (b) had good access with the majority of candidates able to gain all three marks for a correct equation. A few made careless errors evaluating *x* and *y*, or rearranging their equation, and lost the accuracy mark. A few responses used a gradient of $-\frac{1}{3}$ instead of 3.

Part (c) was the least successful part of the question, with many not attempting it even when the surrounding work was correct. The most successful responses substituted the parametric equations for *x* and *y* into their equation from part (b) and simplified. Those who did this generally scored both marks. Some candidates took more convoluted approaches, such as rearranging the equation for *x* to find sin *t* and substituting this into the parametric equation for *y*. They then had to equate this equation with their answer to part (b) and cancel the $3x$. This was less successful. Another fairly common, but incorrect, approach was to simply substitute the coordinates at *P* into the parametric equations and eliminate sin *t* and not use the equation from part (b) at all. This did give the same equation, but based on a flawed approach could not score marks.

Most candidates were able to solve the equation in part (d) to find the correct value for cos *t*, and sometimes this was the only mark scored in the question. Relatively few lost the first mark where they solved the quadratic in terms of another variable and did not write $\cos t = \frac{7}{9}$. Having obtained this, many were not able to proceed to find a value for *y*, while some used their calculators to find the decimal approximation. Some candidates chose the wrong value for cos *t* and used $t = \pi$ to find *y*. The exact values were rare with not many candidates finding that $\sin t = \frac{4\sqrt{2}}{9}$, but those who did manage to achieve this were usually successful in attaining full marks. Perhaps teaching how to find other trig values using a triangle and Pythagoras would be beneficial.

Question 8 Mean 4.69, mode 0/10 (19%)
Another question with a mode of zero marks and a low mean, this was another discriminating question, where higher grade candidates were able to shine. Only 14% attained full marks, with a wide spread of marks seen overall. Although the vast majority were able to achieve some marks in the question, with the by parts or modelling aspect being most students stumbling block.

In part (a) the unsimplified answer was often seen, but many candidates when removing the brackets would forget to square the 10 or did not put in the limits and some forgot the π. It was surprising how many candidates were unable to successfully square 10.

For part (b) most students realised they needed to integrate by parts, though a few attempted false product rules, while some applied parts in the wrong direction and did not seem to realise or know how to recover. For those who began correctly, the main errors seen were sign errors, though work through the two applications of parts in method was usually achieved. The tabular method that is now becoming more widely used proved to be the most successful way to achieve full marks.

Part (c) was very varied in the pattern of marks awarded. Some forgot the *k* from part (a) or forgot to double the volume; most substituted the limits of 10 and 0 (though a few used 20 and 0); a few left the mass in kg, however, in the main this aspect was well managed. Overall full marks were very rarely awarded, in a lot of cases due to the above mentioned or through errors in (b).

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