Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

Summer 2022

Pearson Edexcel International Advanced Level
In Pure Mathematics P2 (WMA12) Paper 01

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This paper proved to be a good test of candidates' ability on the WMA12 content and plenty of opportunity was provided for them to demonstrate what they had learnt. Marks were available to candidates of all abilities and the questions that proved to be the most challenging were 2(c), 6, 9 and particularly 10 where although most candidates made some attempt at part (a), parts (b) and (c) were often not attempted.

Presentation was generally good and candidates often showed sufficient working to make their methods clear. In a minority of cases there was an over reliance on the use of calculators when it was clearly indicated in the question that all working needed to be shown, e.g. in 8(b).

Question 1

The opening question required a binomial expansion and it was very well-answered on the whole. The method was widely known and it was rare to see errors in simplifying terms to obtain the integer coefficients. Errors included neglecting to take appropriate powers of the $\frac{3}{8}$ or to have missing "2"s. Removal of the common factor of 2^{10} was not common although a small number left the constant term as 2^{10} instead of 1024. Some students altered their series by division. The instruction to "Give each coefficient as an integer" lead to a list of coefficients in a small number of cases but this was subsequent work that could be ignored in most cases. A small minority of candidates expanded in descending powers of x.

Question 2

This question on the trapezium rule saw consistently high scoring in parts (a) and (b) but marks were rarely awarded in part (c).

In part (a) most students scored both marks with only a few unable to use their calculators appropriately. Rounding errors were seen but were quite rare. The most common mistake was to be working in degrees despite "where x is in radians" being explicitly stated in the question.

Three marks out of three was certainly the modal mark in part (b). It remains the case though that some students who rely on the formula book fall foul of mistaking the number of strips n, with the number of ordinates, leading to an incorrect h. Poor bracketing occasionally led to lost marks but most set up the correct structure for the required numerical expression. A few students unnecessarily used separate trapezia but usually managed to obtain the correct answer.

Part (c) proved extremely discriminating. Most students were unable to rewrite the new integral in terms of the previous one. Many just ignored the minus sign in the first integral and added $[3x]_{0.5}^{3}$ or even just added 3 to their answer to part (b). Others resorted to the use of the trapezium rule again and scored no marks.

Question 3

Part (i) required candidates to show that the assertion that the algebraic expression $(n + 1)^3 - n^3$ was always prime for positive integers n, is false. Most candidates realised that a counter example was required, scoring themselves the M mark, however due to the relatively late arrival of a valid counter example most did not achieve the required proof. For those that did find a valid counter example, often $n = 5$ or $n = 7$, another common error was to just state the result was not prime without providing evidence of factors or divisibility. Several candidates used $n = 15$ or $n = 19$ or higher numbers, including $n = 120$. Another interesting point was the apparent lack of understanding of the meaning of $n \in \mathrm{N}$. Some candidates used negative numbers, zero, decimal and even irrational numbers.

Another misconception from a number of candidates was the need for algebra to complete a proof. Many tried to expand and simplify the expression, though there were often errors and usually no marks were scored as very few of these substituted a positive integer into their simplified expression to show that it was not a prime number.

Part (ii) gave three coordinate points A, B, C and asked candidates to show that one particular side AB was the diameter of the circumscribed circle. Here we saw the more able mathematicians provide a clear, concise proof whilst others made little to no progress or achieved most if not full marks but in a much less sophisticated way.

For those who made good progress in this question, the majority realised that the triangle had to be shown as right-angled at C and this was done by both finding the lengths and using Pythagoras, or by finding gradients of the two other sides and using the perpendicular gradient rule to show that there was a right-angle. As in part (i) candidates seemed not to realise that a clear statement of the proof was required; often having established that Pythagoras, or the perpendicular gradient rule applied, there was no follow-up concerning a right-angle in a semi-circle or similar: indeed a number failed to mention the existence of a right-angle at all. Usually this gained 4 marks of the 5 as the appropriate calculations were presented. For those that used these methods the most significantly incomplete way seen was to calculate all three lengths of the triangle. Occasionally the understanding of the steps needed for the proof were clear however the execution was poor with "the lines are perpendicular" or "$AB^2 = AC^2 + BC^2$" with no numerical evidence. The cosine rule was used on a few occasions to show angle ACB was a right angle, and some students using this method achieved full marks on this part of the question.

A large proportion of candidates started by performing one calculation but lacked the ability to complete the proof; usually the midpoint of AB was found and this gained two marks of the five available, however there was clearly no understanding of how this could lead to the required proof. The other approach was to form the equation of the circle with AB as diameter and show that point C satisfied the equation, but again this work was often done poorly and the required conclusion not provided. Other more complicated approaches were seen and often went wrong or were incomplete.

Question 4

This question was answered well by a majority of candidates who were able to correctly combine logs and undo a log correctly to achieve $ab = 64$. However there were still a significant number of candidates who lacked any understanding of logarithms with a variety of errors such as taking logs incorrectly on $a - b = 8$ to find $\log a - \log b = \log 8$, $\log a + \log b = 3$ becoming $\log (a + b) = 3$ or even $\log (a/b) = 3$. Of the students who reached log $ab = 3$ nearly all achieved $ab = 64$ with $ab = 81$ seen infrequently. Most candidates who reached this far found a correct quadratic equation and solved it to find a surd form for b or a. There was the occasional decimal answer given by those candidates who did not read the instructions clearly. Nearly all candidates who reached this stage found the other variable as a surd. The question required a and b to be positive and there were still a significant number of candidates who did not dismiss the negative answers and so gave 2 values for a and 2 values for b thereby forfeiting the final mark.

Question 5

A significant proportion of candidates achieved full marks on this question achieving both answers and no incorrect extra solutions although some had difficulty finding extra solutions in the range as they attempted the additional solutions after subtracting 43 rather than before. There were a number of candidates who had poor notation and poor understanding of what trigonometric functions are, often writing tan $(\theta + 43)$ as $\frac{\sin}{\cos}(\theta + 43)$ or treating tan $(\theta + 43)$ as tan $\theta + 43$. Using $x = \theta + 43$ often helped candidates keep their working neater and error free. There were quite a number of candidates who gave –13 only and a number who gave incorrect answers such 167 and –167 and –73 as well as 73 from adding 43 instead of subtracting. Candidates are advised to take care with the order of operations when solving trigonometric equations.

Question 6

This question was attempted by almost all students and discriminated well between candidates of varying ability. In part (a), those who could write the terms of the series in terms of a and r, or sometimes in terms of u_2 or u_3 and r could usually form a correct equation in r relating these variables, and many continued correctly to the given answer. A small minority of students found an equation in r^3 or r^4 which some factorised to the required quadratic.

In part (b), given that most candidates have calculators with the ability to solve quadratic equations, the first mark was scored nearly by all candidates. Fewer candidates realised that the sequence was convergent, and therefore many selected the wrong r value of 2 and rejected the $r = –2/3$ for further calculations and so gained no further marks. Other candidates thought that both values of r were valid and went on to give 2 different values for the first term.

In part (c), since many candidates did not take into account that $|r|$ had to be less than 1, and so used $r = 2$ in their formula for the sum to infinity, they scored no marks in this part of the question. Some candidates used $r = 2$ to find a, then used this a value with $r = –2/3$ to find the sum to infinity.

A small number of candidates persevered with <u>their</u> equation from part (a) rather than the given one, so failed to gain marks in (b) or (c).

Question 7

This question combined a cubic expression, the factor theorem and integrating the cubic with limits with a given result of 176 to form two equations in two unknown constants which were to be found. It was encouraging that a fair number gained full marks meaning that the lengthy algebra was successfully navigated. Furthermore, nearly all candidates at least made an attempt on this question and the majority of them gained 6 marks out of 7. The last A mark was often lost for incorrect values of the constants A and B due to poor arithmetic and algebraic errors when simplifying and solving the simultaneous equations. The frequency of the omission of brackets around their expressions generated by the substitution of the limits was disappointing and unnecessary, the inclusion of the brackets and a methodical expansion should be encouraged and would undoubtedly reduce if not eliminate these errors.

The first part of the question pleasingly showed that the factor theorem is familiar to most of the candidates and many were successful in using it correctly. As the first 2 marks were given if they substitute $x = -2$ only and equating the expression to zero a very big majority gained these two marks. Occasionally candidates failed to understand the importance that $f(-2) = 0$ and thus lost the 2 marks with others making sign errors resulting in this and the final A mark being lost. Candidates who tried division usually made little progress as it proved too difficult.

In the second part of the question, many integrated $f(x)$ and substituted in the given limits correctly, however some didn't equate their expression to 176 and lost the following 3 marks whilst more costly some did not integrate the constant B term resulting in it not being possible to reach an equation in A and B and thus the final 4 marks were lost. A small but surprising number of candidates mistakenly interpreted their writing of B as the number 13.

Other misconceptions and errors highlighted in this question were; students not knowing whether to integrate or differentiate, confusion with which expression to set equal to 0 and 176, some candidates using their expression from the factor theorem as their integrand and others simply not integrating at all before substituting in their limits.

Question 8

This question on differentiation was a good source of marks on the whole although a significant number of students made little progress in part (b).

It was rare not to be awarding marks in part (a) although a very small number could not recall the method to find the derivative of a polynomial. Predictably most errors were seen differentiating the $\frac{27}{x^2}$ term with $-54x^{-1}$ often seen.

Almost all knew to set their derivative equal to 0 in part (b) but many could not deal with the resulting equation. This included some who proceeded to obtain the correct polynomial equation (although some multiplied the x^3 term by x^3 to give x^9) but were unable to recognise that this was a quadratic in x^3. Those that did, generally solved it appropriately, although some gave their answers as $x = \dots$ instead of $x^3 = \dots$ and then used these values to find y. Occasionally square roots instead of cube roots were taken. Some who replaced the x^3 in the equation with y went on to offer these values as the y coordinates of the stationary points. Several rejected $x^3 = -\frac{1}{8}$ thinking it had no solutions. Those who had the correct x values didn't always proceed to the correct corresponding y values as a result of careless substitution. As a result, the last mark was not as widely scored as expected. In part (b) some candidates attempted to find the second derivative and then tried to solve $\frac{d^2y}{dx^2} = 0$. A very small number relied entirely on their calculator in part (b) despite the clear instructions in the question.

Question 9

This question tested a good number of different skills. In part (a), the sketching of the exponential graph was very poorly done and full marks was a rarity. Those that did succeed in drawing a decaying function often failed to state the y-intercept or appeared to think the asymptote of the graph was above the x-axis. Many however scored no marks and there were many blank responses, and many incorrect sketches were seen, including linear and reciprocal graphs. The main error was to sketch an increasing exponential, despite the question having two clear statements that the carbon 14 in the item decreased.

Part (b) showed that candidates were not familiar with such a question. As the question only stated that the initial amount had halved many candidates did not know how to deal with this as they were given no values. Many candidates attempted to work with k and $0.5k$ which was sensible when done correctly, however, often k's didn't cancel or candidates ended up with 2 in place of 0.5 thus resulting in no marks. One suitable approach was to substitute numbers, which often led to the correct equation. Once candidates arrived at the correct equation a surprising number of candidates used log work to arrive at the given result which was not as efficient as taking the 5700th root.

Generally parts (c) and (d) were the best answered in this question. That said, some candidates were unable to write down the correct equations which in themselves were fairly straightforward to solve. Some candidates did not use an accurate value of lambda regardless of the fact that it was clearly given in part (b).

Part (c) was really well answered by a significant majority, although too many didn't give values to 3 significant figures as required but fortunately for them this didn't result in a loss of marks here.

In part(d), the correct equation was often seen though some candidates had errors in the value of lambda due to rounding errors and others had the power of t –1. A misunderstanding of the order of operations was displayed far too frequently with 25 x 0.999878^t being replaced with 24.99695^t though many were able to successfully solve their equation using logarithms correctly. The requirement to give the final answer to the nearest 100 years also caused more issues than expected. Many variations were seen with 2690 and 2600 being the most common. A small number did not read the instructions within the question carefully and jumped from the equation to the correct solution without showing their working and this cost them 2 marks.

Question 10

This question was generally poorly answered with many candidates unable to proceed beyond part (a). Of those who attempted part (a), most formed the correct equation of the circle and replaced y with $2x + k$ to form an equation in x, k and r and attempted to expand the brackets $(x - 3)^2 + (2x + k - 5)^2$. There were algebraic and sign errors when expanding brackets in this form and candidates who expanded $(x - 3)^2 + (y - 5)^2$ first before substituting for y found the algebra less demanding and were usually able to proceed to the given answer without errors. A significant number of candidates adopted an incorrect strategy from the start and set $(x - 3)^2 + (y - 5)^2 = 2x + k$ and scored no marks.

Part (b) was not answered as well. Candidates who used the discriminant = 0 for the given equation from part (a) often achieved all the marks but many candidates did not know how to approach this part. There were some attempts to find the coordinates of B, however these tended to not achieve full marks as they were often incomplete. A surprisingly large number of candidates attempted to use a scalar product. A large number of candidates did not think of using the discriminant = 0 perhaps because of the non-standard way the quadratic in the initial question was presented and some timing issues may have accounted for this.

Part (c) was often left blank or with minimal aborted attempts. It was not particularly clear if this was a timing issue or if candidates simply did not how to tackle the problem. Candidates who could make progress, used the right-angled triangle formed by AB, AX and the radius to form an equation in r and k and then applied the result from part (a) to complete the solution. A variety of other valid approaches were seen for this part of the question and usually involved finding the coordinates of the point B in terms of k first and then using $AB = 2r$ and the result from part (b). Despite this being the most difficult part on the whole paper, some very elegant solutions were seen.

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