Examiners’ Report

Principal Examiner Feedback

Summer 2024

Pearson Edexcel International Advanced Level

In Pure Mathematics P2 (WMA12)

Paper 01

WMA12 Report June 2024

Summary

The paper was well received and provided clear opportunities for all grades to access marks, although the higher grades struggled to really excel. All questions were attempted with little indication of lack of time, although question 10 was sometimes only partially answered. This may have been more to do with candidates not knowing how to proceed rather than not having time.

Questions 5 and 10 provided the biggest challenges, while question 1 was a nice ease into the paper. Good understanding of many of the concepts of the specification was shown, but proof continues to confound the majority of candidates, and the context of question 10 caused a few errors in indexing to be made.

Question 1

This question was very accessible, with a large proportion of candidates gaining full marks.

Part (a) was answered completely correctly by most candidates, with most setting their work out clearly, having a good structure and bracketing around the $\left(-\frac{1}{6}x\right)$. Some chose to list the terms of the expansion, which was not penalised because the question simply asked for the first four terms. Missing the negative sign from the coefficient of x was the most common error and generally led to candidates scoring just the method mark in this part of the question, as did incorrectly applying the powers to the $\left(-\frac{1}{6}x\right)$. Occasionally, incorrect binomial coefficients were seen, or they were paired incorrectly with the terms in the expansion. Similarly, some candidates failed to simplify all the terms in the expansion, with the final term left unsimplified most frequently.

Part (b) was marginally less well attempted, but most candidates did have some idea how to approach the problem, and many scored both marks. For those who did not, there were three main reasons: failing to combine the two required coefficients into a single term; selecting just one of the required terms (usually $10\times b$) or because they chose to multiply $10x$ by both their bx^2 and their cx^3. For those that selected the appropriate approach, a minority elected to give their answer as a decimal, and frequently this was given as 8.83 rather than the correct $8.8\dot{3}$ and lost the final accuracy mark. A considerable proportion of candidates left their answer as $\frac{53}{6}x^3$, and while this was not penalised on this occasion, candidates should be reminded to satisfy the demands of the question, which in this case was to select the coefficient $\frac{53}{6}$.

Question 2

The majority of candidates found both parts of this question accessible, although mistakes were more common than in question 1. Generally, candidates attempted to show all stages of their working as asked by the question.

Part (a) was generally well attempted with most candidates able to write down the correct equations using the given information usually scoring both the B marks. Errors included slips involving the values of n and u_6 and S_{10}, such as $a + 5d = 6$, which was seen a few times. Many candidates went on to score full marks, arithmetical slips usually the cause of any lost marks. A minority of candidates could not recall the correct formulae, and some even attempted trial and improvement which was not often successful.

In part (b), candidates who had values for a and d were usually very competent at setting up a 3-term quadratic and many went on to solve it and select the correct root rounded appropriately. Most candidates recognised the need to use the summation formulae with their values for a and d and using any inequality or equality set to 8000, although slips with writing 800 or 80000 were both seen with some regularity. Such cases were allowed the method.

There were occasional examples of reaching the 3-term quadratic, but not attempting to solve it, possibly due to the warning at the top of the question and candidates thinking that a calculator was not available to them at this stage. A surprising number of candidates, who did solve the equation correctly, selected the correct root but did not round it up instead leaving it as a decimal, or some rounded it down. A few selected the negative value of n suggesting a misunderstanding of the domain for n in a series. Some issues arose in the algebraic manipulation to get to a 3-term quadratic, for instance some used the correct sum formula at the outset, but erroneously cancelled a term in n leading to a liner equation/inequality which could score no further marks.

Also noteworthy is that there were a few candidates approached this part via trial and error, rather than engaging with the specification content. These met with varying levels of success, but such approaches are not encouraged, as the use of the taught specification should be demonstrated.

Question 3

This question was again generally very well attempted by candidates, although only a small proportion scored full marks. However, scores of 4 out of 6 or better accounted for the vast majority, with the final mark in (i) and the mark in (ii) being where the most errors occurred.

Many candidates answered part (i) well and it was pleasing to see that very few lost marks for failing to show sufficient working using logarithms to achieve a correct quadratic equation. In many cases, the laws of logarithms were applied clearly and succinctly, but there were the usual misconceptions for those less confident in the topic, with many distributing the log over brackets (e.g. $\log(2-x)=\log 2-\log x$)) or erroneously combining the $2\log(2-x)-\log(x+10)$ as $2\log\frac{2-x}{x+10}$ without using the power law first, or even just simply removing the logs to achieve $2(2-x)=2^4+x+10$. Candidates making mistakes such as these would typically not arrive at a quadratic equation and as such the final method mark was not available to them. However, this mark was not otherwise dependent on previous work and so many who had completed some logarithmic work successfully were able to go on to have some further success. A few did make algebraic slips expanding brackets to arrive at an incorrect quadratic but were able to score the mark for solving it. For those that arrived at the correct quadratic, the vast majority went on to solve this correctly, achieving $x=26$ and $x=-6$, but it was fairly evenly split between those who incorrectly left both solutions, those who incorrectly selected $x=26$ (incorrectly justifying that x could not be negative) and those who correctly selected $x=-6$ (having carefully checked which values were valid).

Part (ii) was accessible to many candidates even if they had not been successful with part (i), with a good proportion correctly deducing that the expression took the value 12. Some incorrectly stated $a=12$, but this was not penalised. A minority realised that they could select a value for a and evaluate it, but the vast majority attempted to address the question algebraically, with many making early errors or reaching a dead end, unsure of how to continue. It would perhaps be advisable for centres to reiterate the link between $\log_a b=x$ and $a^x=b$ as those that wrote $\sqrt{a}^x=a^6$ were often successful. Similarly, non-calculator practice at evaluating e.g., $\log_2 8$, would be beneficial.

Question 4

The majority of candidates were able to gain at least 6 marks in this question but there were many who did not know how to justify the number of roots at the end, so only a minority achieved full marks. Most were aware of the factor and remainder theorems and able to apply them, and a process for finding the factorised form was shown by most.

Part (a) was well answered, with most students gaining the mark by applying the remainder theorem correctly. Many simply gave the answer, realising that they could identify by inspection that the remainder is 21 as the first bracket equates to zero when $x = 2$. However, many also gave needless roundabout work, such as expanding the bracket first, or trying to divide through by $x-2$ first, perhaps thinking working needed to be shown and, therefore, over complicated the demand of this 1-mark question. Of the candidates who answered incorrectly, common answers included $\frac{21}{x-2}$ and −21, amongst other incorrect values or expressions.

For part (b) most students applied the factor theorem and substituted $\frac{1}{2}$ into the expression, before rearranging to make k the subject. However, the equating to zero was sometimes not explicitly stated and cost some students the second mark in this "show that" question. Those who expanded first before substituting were sometimes caught out by errors in algebraic manipulation, losing accuracy. A minority of students, but significant proportion, attempted to divide by $\left(2x-1\right)$ and set the remainder to zero, which was less successful as they often struggled to deal with the remainder correctly and form an equation.

Part (c) proved a bit more problematics for candidates, particularly part (ii). In part (i) most candidates did attempt to expand the function using k =11, although some used an incorrect value of k that they found in part (b), and others omitted the 21, which limited how far they could progress with this part of the question. Proceeding from there, many used algebraic division rather than factorisation, with varying degrees of success. The inspection method was rarely attempted but was generally done so correctly when seen. A significant number of students did not state the fully factorised expression for f(x) and so lost the final mark. Some incorrectly divided by $(x-2)$ instead of $\left(2x-1\right)$. In part (c)(ii) a lot of students struggled to gain both marks because they concentrated only on giving the number of roots, not the reason for the answer. Others did not write down all the necessary detail, despite having the correct strategy in mind. The most common approaches were via the determinant or use the quadratic formula to find the roots, they many did not give sufficient detail in their proof, such as failing to simplify the determinant or not stating the inequality to explain why it showed no solutions, but simply stating the value -3. Some students just found the roots on the calculator, but did not state the number of real solutions, so failed to answer the question. Other approaches to the problem were rare. A few students attempted to factorise the quadratic using complex roots, and others attempted to evaluate the discriminant for the quadratic $\left(2x^2+5x+11\right)$ so did not gain any marks.

Question 5

This proof question proved to be challenging for many students and very few were able to gain more than 3 out of 6 marks. A lack of understanding of the domain of discourse was apparent with candidates not appreciating the difference between x and y being positive for part (a), versus being over all real values in part (b). Rather, the focus tended to be purely on the inequality.

Part (a) did give an accessible start with most students attempting to expand $(x-y)^3$ but often coefficients and/or indices were incorrect. Only a few recognised the usefulness of the binomial expansion here, with many preferring to multiply out 3 brackets separately. Most candidates recognised the need to simplify the inequality but sign errors and incorrect coefficients on their expansion sometimes hampered progress to the answer. Those that did expand correctly usually saw how to simplify the cubic terms and divide by kxy to obtain the y < x, but all bar the very best students omitted the reasoning with the division and failed to score the final A mark. Whether those candidates were not aware that the sign needs to be considered before division, or if they had noted x and y were positive and didn't realise that a proof required them to state that fact was not possible to discern.

A few factorised $(x-y)$ from each side of the inequality in the Alt approach, but this was uncommon. Also there were a few attempts and simply substituting in values to check if the result held, but with no algebraic proof of its truth in general.

Only a minority of candidates actually managed to find a correct counter example for part (b). Most students failed to score at all on this section as only a very few candidates understood that they needed an example where the first inequality still held but the second one did not. Instead, they searched for examples where $x > y$ but the first inequality was not true. Most of the attempts had a positive x and a positive y. Some tried a wide variety of numbers, including fractions and square roots, but almost always with both x and y positive. Very few provided an actual counterexample with a positive x and a negative y.

Question 6

This question provided some easily accessible marks in part (b), with the trapezium rule being a well-loved topic, but performance in parts (a) and (c) was less secure.

Although many achieved full marks in part (a), a wide variety of responses was seen, and curve sketching skills were not well evidenced overall. Common incorrect attempts involved decreasing curves, curves with a clear minimum point, and labelling the y-intercept with the correct height of the asymptote (0,4). Of those who did draw an increasing graph with the correct asymptote labelled and correct y-intercept, a few lost the A mark because their graph did not approach the asymptote convincingly or because the asymptote was either incorrect or its equation was not written. However, very few candidates made no attempt to sketch the graph, and many of those that did attempt it were able to gain the method mark for either a correct shape in quadrants one and two or for a curve approaching the correct asymptote so even many incorrect graphs scored the first mark. Some were also able to gain the B mark for the correct intercept without gaining the first method mark. A few candidates attempted to plot the points from the given table of values for y.

Part (b) was very accessible, generally well understood, and many achieved full marks by applying the trapezium rule correctly. Thought not common, the usual error was seen of incorrectly calculating the strip width h, usually from candidates who tried to use the formula $h=\dfrac{b-a}{n}$ instead of finding h from consecutive values of x in the table. Also, there were some bracketing errors in applying the rule, which involves nested brackets, and some who applied the trapezium rule correctly but calculated the incorrect answer. Very few applied the bracketed terms of the trapezium rule incorrectly but products instead of sums were seen, as well as either the inner or outer brackets being misplaced or omitted, despite the rule being given in the formula booklet.

Part (c) proved to be quite demanding with many candidates either skipping the question or resorting to calculator work. In (i) many did not correctly split the integral by replacing 2^x+2x with $2^x-2x+4x$; some of those that did then did not integrate and used [4x] instead of [2x^2] with the limits 2 and 3.5. A few used their answer to (b) to find $\int_2^{3.5} 2^x \, dx$ and then used this to find the required integral, or occasionally the correct follow through. Some candidates did not use their answer for (b) at all but tried to integrate the expression directly (incorrectly). A small number used the trapezium rule again, which gained no credit.

More candidates were able to spot in (ii) that they needed to double their answer to (b) and scored the mark, sometimes via follow through, but overall, these were a minority. Even when correct there was often a good deal of work that went on beforehand that was not needed.

Question 7

This was another question with a very accessible first part followed by a much more challenging second part, with very few candidates able to progress beyond the first mark of part (b).

Part (a) was well answered with most students realising the need to complete the square to find the centre and radius. This generally led to the correct coordinates being found, but sometimes the constants were incorrect leading to an incorrect radius, and sign errors in the coordinates for the centre were also common errors. Many did not show the completion of the square, but were able to deduce the centre directly, though these were less successful in finding the radius overall. A minority of students forgot to square root the constant to find the radius or gave a rounded decimal answer. Some students didn't subtract 16 and 25 from the left-hand side of the circle equation, so they gave the radius as $\sqrt{29}$.

Candidates were much less confident in part (b) and many did not attempt it or failed to score on this section as they struggled to form an appropriate strategy. Those who made some progress often defaulted to solving the two equations of the circle simultaneously (usually be rearranging both to "=2" and setting equal), and many managed to simplify to a linear equation. However, at that point the majority were unable to make further progress. Only a minority of students substituted their linear equation into a circle equation to move forward with such solutions. Of the candidates that did attempt this, there were frequent errors and the correct quadratic equation was rarely found.

A sketch would have been useful in this part as those that sketched the circles were often able to see the much simpler approach to this part of the question of using the distances between the centres. A few who followed this path compared their distance between the radii to one circle radius rather than the sum of the two radii and only scored the first M mark. Most who compared correct distances explained and reasoned correctly, although some did not write down a suitable conclusion or did not justify their conclusion by giving suitable decimal values of the distances (15.81 between the centres and 15.58 as the sum of the radii) so they did not score the final A1 mark due to lack of a full explanation.

However, some candidates who tried drawing a sketch of the two circles wrote annotations saying that the circles did not touch or intersect but often no calculations or irrelevant calculations only were provided so this scored no marks. A common incorrect reason was to assume the circles lay in entirely different quadrants, so could not intersect, but with no proof offered for the claim (which was not true in any case), and often resorted to simply commenting on the different quadrants the centres of the circles were in.

Question 8

Once again, the early parts of the question proved accessible, but candidates fared less well on the closing marks. Some candidates did not attempt parts (ii)(b) or (ii)(c), and there were some who did not attempt question 8 at all clearly being uncomfortable with trigonometry as a topic. But for those who knew the basics, there were marks on offer.

Though full marks were often scored in part (i), there were a surprising number of basic algebraic slips when trying to multiply through by the cos *x*, resulting in the loss of either both the M and A marks, or at least the A marks. A common such error was omitting to multiply each term by the cos *x*, with usually the constant term 13 missed, which then prevented candidates from reaching a 3-term quadratic in cos(x). Failing to multiply the other cos *x* term at least led to a suitable quadratic. Despite these failings, it was the case that only a very small minority made errors with the tan *x* identity, or used incorrect Pythagorean identities, and the method of solving a quadratic, if a suitable one was reached, was good.

For those who did successfully reach a value for cos *x* most went on to find a value for *x*, though there was sometimes a reluctance to evaluate $\arccos\left(-\frac{1}{3}\right)$ after correctly solving the quadratic. The acute equivalent $\arccos\left(\frac{1}{3}\right)$ was often found initially, which led to more work and sometimes confusion as to what the solution was, with extra solutions in the range sometimes included. There were also numerous candidates who worked in degrees (only sometimes converting to radians at the end) despite the bounds being clear. There was also a common disregard for the sin/cos functions to require an angle/expression to go with it and it was common to see “sin” and “cos” without a corresponding *x* throughout working.

For part (ii) the majority of candidates correctly worked in degrees here instead of radians and also used the given information to arrive correctly at $\sin(6k+18)=\frac{10}{12}\left(=\frac{5}{6}\right)$, although a few did use $t = 1$ instead of $t = 6$. Generally, candidates showed all stages of their working, but some candidates did not heed the advice at the top of the question and lost marks through missing out key stages, presumably solving by calculator from too early a stage. Many did succeed in reaching a value of *k* but a common error was to omit $k = 17.59$ as one of their final answers. Another less common error was to treat “sin” as a multiplier and rewrite $\sin(6k+18)=\sin 6k+\sin 18$ which led to no marks being scored.

The context of part (ii) did cause issues in the final parts, and (ii)(b) saw a mixed response from candidates. There was a lack of understanding with the connection between the given equation, using their value of *k* and then finding a maximum value, with many failing to use the maximum of the sine function, and instead trying to substitute values. Those who could spot the connection would just give the value. Some candidates found 22 via incorrect methods (substituting values for *t* and then rounding an answer) and were not awarded this mark. A few candidates attempted to solve using differentiation as they could not spot any other way forward.

A mixed response from candidates was again seen in (ii)(b), with little overall progress made. The discerning candidates set $\sin(6.41t + 18)° = 1$ or $6.41t + 18 = 90$ and from there they often proceeded to a correct value for *t*, though many struggled to put this into context giving he answer as 11.23 hours or 674 minutes, without converting these answers into a time of day. Again, many candidates were not connecting the maximum value of sine as occurring when $\sin(kt + 18) = 1$, though, and so made no progress at all.

Question 9

This question involving differentiation and integration was attempted by nearly all candidates and provided some access late in the paper, suggesting that candidates were not struggling for time at this stage. It was common for candidates to score full marks in part (a) but score no marks or two marks out of four in part (b).

In part (a), the vast majority of candidates knew to expand the brackets before attempting to differentiate, and this was generally done well. Occasionally there were errors in coefficients, either before differentiating or afterwards, but the first method mark was scored by the majority. There were very few attempts to use the product rule. Again, most candidates knew to set $\frac{\mathrm{d}y}{\mathrm{d}x}=0$ to find the x coordinate of the stationary point, but many found the equation $12x^{\frac{1}{2}}-5x^{\frac{3}{2}}=0$ hard to solve. It was common to see an attempt at a substitution used here, such as $t=x^{\frac{1}{2}}$, but this was often met with limited success, either due to poor substitution or because they chose to square root a second time to find x. Common incorrect answers included $\frac{144}{25}$ and $\frac{2\sqrt{15}}{5}$. Those that took out (or divided) by a factor of $x^{\frac{1}{2}}$ were generally the most successful in achieving the final mark of this part. A minority of candidates went on to find a value for y, but this was not required and so any work towards this was not considered.

Candidates found part (b) significantly more challenging than part (a), with the majority unable to identify a correct strategy to solve the problem, despite most realising integration was required. As such, it was very common for the first two marks to be scored – again, candidates generally knew that they needed to expand the brackets before they integrated and, having done so earlier, they quickly picked up the first M1A1 for correct integration of the two terms. It was surprising that some candidates who had expanded in part (a) attempted to integrate the original expression, scoring no marks. No attempts at integration by parts were seen. Often, candidates stopped having integrated the expression, or proceeded to substitute limits and evaluate a definite integral (0 and 4 were the most common limits used, but occasionally 0 and their answer to (a) were used) before abandoning the question. The most common incorrect approach to attempt to solve this part was in setting their area for R_1 (often a correct $\frac{1024}{35}$) equal to the integral from 4 and k leading to the (incorrect) equation $\frac{16}{5}k^{\frac{5}{2}}-\frac{4}{7}k^{\frac{7}{2}}-\frac{1024}{35}=\frac{1024}{35}$ which candidates either solved on their calculator or realised they did not know how to solve. Very few candidates appeared to lose a significant amount of time here, as they generally recognised this was not going to provide any useful means of solving the problem. Some did recognise the error here and reverted to setting $\frac{16}{5}k^{\frac{5}{2}}-\frac{4}{7}k^{\frac{7}{2}}-\frac{1024}{35}=-\frac{1024}{35}$, which allowed them to find the correct solution. For the strongest candidates, however, it was much more common for them to identify that the total definite integral from 0 to k was equal to 0, and this led to some very concise solutions.

Question 10

This final question provided somewhat of a stumbling block at the end of the paper, though the indications were that this was more to do with its context than timing, as most were able to offer some kind of attempt at the final part. The question dealt with annual compound percentage changes and required interpretation of the initial conditions for fully correct work. The value after n years was often confused with the n-th term of a GP so ar^n became ar^{n-1} so indexing errors were very common in candidate responses and the mark scheme allowed correct method, with some cases of incorrect indices, to gain marks. Only a small minority did not try this question at all, whether because it was the last one on the paper and they had run out of time.

In part (a) many candidates gained the method mark by using 2000×1.03^5 instead of the correct 2000×1.03^6, while some attempted to enumerate values in each of the first few years, again being unsure which was the correct year. Those who realised the power 6 was needed usually obtained the correct answer. A common error involved using 3 or 0.03 instead of the correct 1.03 which should have been interpreted from "increase by 3%" in the question. There were also some who tried the sum of a geometric series or n-th term of an arithmetic series, who seldom made any progress with the question thereafter.

Part (b) involved the model $N = ab^t$, which was to be produced from the provided contextual information. Again, many candidates who attempted this question gained the method marks despite using incorrect powers of e.g. b = 3 and 6 rather than the correct 4 and 7, and found the value of b and a for their attempted equations. Many were able to reach the correct $b^3 = \dfrac{3470}{3690}$ because their indices differed by 3, but only the correct choice of indices would then result in the correct value of a. However, numerous cases of incorrect algebra simplify the equations was also seen, with $b^3 = \dfrac{3690}{3470}$ common, or square rooting instead of cube rooting. Those who mark found a and b correctly often did not go on to gain the A mark as they did not attempt to write down the correct equation for N, instead leaving the answer as just quoted values for a and b. Again a few candidates tried to use the sum of a geometric series.

Part (c) proved challenging for the majority of students with few attempting a solution, even when suitable progress had been made in the first two parts. Very few fully correct solutions were seen. Candidates who attempted this part could often take the initial step of equating the two exponential models ($2000\times1.03^T = ab^T$) involved in the previous question parts, with terms of the correct form, and then either tried to solve by attempting to take logs of both sides or by finding a single term with power T, and using logs to solve for T. Incorrect log and index work was quite common in such responses meaning progress was scarce. Those making indexing errors in the setting up of the equation (e.g. T-1 on one side) could gain method marks but often failed to achieve a single term in T. However, most again did adhere to the instruction to show working, with few using the calculator to find a solution from the initial equation (and thus scoring no marks).