Examiners' Report
Principal Examiner Feedback

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Pearson Edexcel International Advanced Level
In Pure Mathematics (WMA11) Paper 01

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Question breakdown

Question 1

This question provided an accessible start to the paper, with a routine task of finding the equation of a line and of its perpendicular bisector. Students were generally more successful in part (a) than in part (b), but both parts were answered well.

In part (a), attempts to calculate the gradient were usually successful although there were some slips with the negative numbers and some errors where students muddled the x and y coordinates: sometimes incorrectly calculating $m = \Delta x/\Delta y$. Algebraic slips in rearranging to obtain the required form were also seen from time to time and some students wrote $y = -3m + 5$ rather than $y = -3x + 5$ which unfortunately lost them the final mark in this part, though most did give the equation in the required form and scored all 3 marks. However. some who correctly set up the equation in the form $y=mx+c$ and finding the values for m and c, failed to state the equation of the line.

A less popular but equally successful method was the alternative method of solving simultaneous equations to find values for m and c, where they were almost certain to score the first two marks but some neglected to form the resulting equation.

In part (b), most students realised that to find the perpendicular line, they needed to find the negative reciprocal of the gradient of l_1 found in (a). However, there were several responses where students thought the gradient of l_2 was instead the reciprocal or just the negative of the gradient from (a). Most commonly though there were issues in finding the midpoint of AB, such as using the incorrect formula $\left(\frac{x_B - x_A}{2}, \frac{y_B - y_A}{2}\right)$, mixing up x and y coordinates or making arithmetic errors substituting the coordinates into the correct formula. other students made no attempt to find the midpoint of AB at all, but simply used either point A or point B with their changed gradient. As usual, there were also numerous students who lost the final mark for failing to obtain the equation of l_2 in the required form, instead leaving the coefficients of x and y in fractional form or omitting the equals zero.

Question 2

Students' ability to manipulate surds and indices was tested in this question and overall showed that many lack a fluidity in this topic. Only a minority were able to attain full marks, although for many it was the lack of sufficient working for a "show that" question that was the issue.

In part (i) the majority of students were able to make some progress with many achieving full marks with $6x^{10}y^{-1}$ or $\frac{6x^{10}}{y}$ being given. However, most only scored one or two marks in this part. The most common errors included not cubing the 2 in $\left(2x^4\right)^3$ term, not simplifying fully coefficients resulting in answers such as $3y^{-1}\times 2x^{10}$ or an incorrect power in the y term with y rather than $\frac{1}{y}$ being common. The majority scoring 2 marks were able to determine the correct indices for x and y terms. In other cases, the fraction was incorrectly separated into the sum of two separate fractions, and then a common denominator was attempted. The x^{10} was usually worked out correctly even in such cases, enabling 1 mark to be scored.

For part (ii) it must be noted that the question stated "In this question you must show all stages of your working" and "Solutions relying on calculator technology are not acceptable", but many relied too heavily on the use of a calculator to simplify the surds for them. The ability to show logical steps was demonstrated very well by many, but many others were unable to elucidate the necessary steps to reach the goal and many correct final expressions were not able to gain full marks.

There were some excellent succinct answers, usually from those who immediately used the standard methods shown on the mark scheme, simplifying √27 and rationalizing the left hand side of the equation.

The most successful students would start by rationalising the left hand side of the expression and then equating and working to isolate the term in "*a*". Often the term $\sqrt{27}$ would not be explicitly simplified but be simplified as part of multiplication with another term, and the at which point this occurred would determine whether the initial mark was awarded. For many it only happened in the final answer, losing the first and last marks.

There were also many students who only rationalised the left hand side of the expression and then stopped, presumably assuming they were done (many stated p and q as the coefficients in the rationalised left hand side), or just ignoring the terms on the right hand side or request to find an exact value for a.

Other students who attempted to rationalise the denominator also multiplied the right hand side by $\left(\sqrt{3}-1\right)$ as well, losing the method mark, while various other errors in the manipulation were made.

The second approach of multiplying across by $\left(\sqrt{3}+1\right)$ and then rearrange to find a = ... and then rationalise the denominator proved to be less successfully with some students struggling to rearrange correctly and many resorting to use of calculator after making a the subject, so failing to show the rationalisation process.

Though the majority of students did manage to find the correct answer, achieving at least one mark, it was far too common for them to not show sufficient working and 2 marks was probably the most common score for this part.

Question 3

This question was well attempted, with familiar ground for the integral, but the "show that" demand in part (b) again proved problematic for some.

Part (a) was well attempted with most students scoring full marks. As expected there were a few who lost the final mark by omitting the arbitrary constant, while others failed to simplify the coefficients or made minor algebraic slips – having to $x^{\frac{1}{2}}$ or similar was common.
The process of expanding and dividing through by the $\sqrt{x}$ was carried out by the majority, with only very few integrating numerator and denominator independently before dividing. Nearly all students correctly squared the bracket in the numerator. However, some students were unable to prepare $\frac{(x+5)^2}{x^{\frac{1}{2}}}$ to be integrated by a correct manipulation of the $x^{\frac{1}{2}}$ on the denominator. The most common error was seeing $x^2 + 10x + 25 + x^{\frac{-1}{2}}$.

Part (b)(i) was a good discriminator. Most students scored the first two marks for correctly differentiating, with only a small number making slips (and again few failing to expand). The quotient rule was only seen only infrequently and was much more susceptible to error if used.
However, following the successful differentiation, many then proceeded directly to the given answer without showing the method of setting the expression equal to zero and multiplying by $x^{3/2}$ explicitly and so lost the last 2 marks. It is unclear if they did not know how to manipulate the expression to achieve this, or assumed it was obvious enough, but it cannot be over emphasised to students how important it is that, in a "show that" question, every single stage of their working must be seen, with no errors, to gain the final A1 mark (and sometimes more). Evidence of method was required in this case in order to access the final two marks. Those who did indicate the correct method were often successful in achieving all four marks. But even in most who did show working there were numerous incorrect attempts seen, such as multiplying by $x^{-3/2}$ or attempting to square each term and so on. The plethora of incorrect methods shown serves only to illustrate the need for a correct method to have been demonstrated before stating the final answer. In a "show that" question, it's crucial to show all steps of the working. Knowing something and showing it are not the same.

For (b)(ii) there were many fully correct answers of $x = \frac{5}{3}$ and students who had no previous marks on this question were still able to achieve this B mark. Although the correct solutions to the quadratic were almost always found, there were also many students did not reject $x = -5$ (as $x > 0$) and so forfeited this mark.

Students should ensure they have an equation before multiplying and understand that "value" implies a single correct solution, so other solutions must be eliminated.

Question 4

This proved to be a far more challenging question than was envisioned with a larger number of blank, or nearly blank (where students write a minimal amount and then move on with no actual attempt), solutions seen for this question that any other. However, most were able to make some kind of attempt, even if sketchy, at the question.

A surprising number of students assumed both curves were linear and used $y - y_1 = m(x - x_1)$ to work out the equations, gaining no credit in the whole question, and these were also unable to access any marks at all, again demonstrating how this question proved problematic. With the form not initially given for the students, it would appear a lack of understanding about what “quadratic function” and “cubic function” means is prevalent.

Even where the terms were understood there were still difficulties in forming suitable equations and in both parts a common error was to omit a constant multiple of the correct form (the $k = 1$ cases), which could score just the first mark of each part. Students generally found determining the form of g(x) more complicated than f(x), not appreciating the role of the repeated root.

In part (a) the common error of missing out the coefficient k and using $f(x) = x(x - 4)$, only gaining the first M mark, was the most common mistake. Others tried to form a quadratic with $f(x) = ax^2 + bx + c$ without realizing that, as the curve passed through (0, 0) so that c had to be 0 (although most went on to find it soon). As well as the $kx(x - 4)$ form, many students used the completed square form $f(x) = k(x - 2)^2 - 4.8$, although again there were many who omitted the k, and most of those with one of these forms achieved full marks here. It was uncommon for those who attempted to get k that they did not get it correct. Those using a general quadratic form were slightly less successful, either through algebraic slips, or for a failure to use the relevant points to find the coefficients.

With part (b) the same issue with the omission of k in the form $x(x - 4)^2$ being given was prevalent, and in this part there was no alternative completed square form that could be used, which caused a number who had used such a form in a correct answer to (a) suddenly did not know how to proceed in (b). Where the correct form was deduced, with constant, most were able to form a method to find the constant, usually correct, but a surprising number used the vertex for the quadratic again in part (b), losing the marks.

In incorrect answers, many students used a quadratic form again or thought incorrectly that $g(x) = x(x-4)(x-6)$, not appreciating the repeated root, and mistaking what the information was saying.

There were several cases were seen where a student started from $g(x) = ax^3 + bx^2 + cx$ or with + d as well, and then derived 2 other expressions (along with $d = 0$) and worked through to solve for a, b and c. This was more prone to error but was successfully worked through by many.

Students who did not have a quadratic and cubic in earlier parts of the question were unable to gain credit in part (c), but those who did at least have quadratic and cubic forms were able to score the first two marks with ease, and usually went on to score full marks if the answers to the preceding parts were correct, though a small amount omitted the y coordinate or made a algebraic slip in finding it. Where students failed to score any marks if an attempt had been made it was mainly due to not having a cubic and a quadratic equated.

The most noteworthy point in this part is that those who did set their quadratic equal to their cubic favoured expanding their expressions and collecting terms on one side, even when there were clear common factors (the x and $x - 4$ factors were seldom cancelled), and while some students did attempt to factorise, many used their calculators to solve a cubic, which was permitted in this case. An over reliance on calculators is the cause of many of the problems in other parts of the paper, but did enable many to complete the question here.

<u>Question 5</u>

This question provided a reasonable spread of marks, though again a larger than expect number of blank responses was observed, making this another topic that some students prefer to avoid. The "show that" in part (b) was slightly less problematic than some of the others on the paper for students as the necessary steps to be shown were more clear, thought he given answer was arrived at in numerous incorrect ways.

The majority of students seemed clear on the strategy required for part (a) and many students calculated the perimeter of the plot of land efficiently, though a few took a more circuitous approach to find the arc length by converting the angle from radians to degrees and then calculating the arc length using the formula for degrees e.g. $\dfrac{1.2\times\frac{180}{\pi}}{180}\times\pi\times5$ or $2\pi\times5\times\dfrac{1.2}{2\pi}$ Others calculated the arc length AB and stopped there, perhaps forgetting to add on the two radii, or perhaps misreading the question. Surprisingly, a significant minority of students stated and used the formula for area here which earned no credit, again perhaps misunderstanding what was being asked.

In part (b), many students were able to use a correct formula to calculate the area of the sector OAB. Once again, this was usually done efficiently using radians but sometimes involved a conversion of 1.2 radians to degrees followed by use of the slightly more cumbersome degrees formula. A high proportion of students then realised that the area of R_2 would be a quarter of the size of the overall area following a consideration of the ratio of the two areas albeit that in a number of cases, it is seemed likely that this was assisted by consideration of the printed required value. However, a common error was to omit the units given on their answer and lose the A mark.

There was occasionally some confusion about whether R_2 was the larger or smaller of the two areas, with 11.25km^2 being a common answer in these cases, often then divided by 3 to give the printed answer.

Occasionally, students used unnecessary longer methods, such as finding the length OP first and then using this to find R_2 using the area of a triangle = ½ $OA.OP$ sin1.2, and were penalised for using rounded values to establish an area of 3.75km^2. Some students attempted to find the length of *OP* by incorrectly assuming that it was ¼ of the length of *OB*. This was usually followed by use of the area of a triangle formula to force the printed answer, though was clearly not creditworthy. As is often the case with 'show that' questions, there was some 'fudging' and manipulation of incorrect working to arrive at 3.75km^2, and many also used circular arguments, using the are value to find *OP* then using *OP* to find the area again without ever considering the area of the sector, and as such could not gain any marks.

Part (c) required students to use the area of R_2 from part (b) and the formula for the area of a triangle to determine the length of *OP* (which had often been found in (b)) followed by use of the cosine rule on triangle *OAP* to find *AP*. This was the most challenging part of the question, with many stopping after part (b), or making only partial attempts. Many assumed, for instance, that *AP* was perpendicular to *OB*.

For those who could see how to approach it there was generally a successful method although sometimes the cosine rule was misquoted with sign errors which led to incorrect results, while other could apply the cosine rule but had incorrect methods to find *OP* first, such as assuming it to be ¼ the length of *OB*.

There were a number of other correct methods seen, for example via consideration of the perpendicular to *OB* through *A* which created a right-angled triangle with vertices *A*, *P* and the base of this perpendicular followed by use of trigonometry to find the length of the perpendicular and then Pythagoras to find *AP*. Alternatively, but similarly, the consideration of the perpendicular to *OA* through *P*. These methods were more involved but were often successful when attempted.

It was unfortunate that a number of students lost the final mark in this part for either failing to state the units of their answer and/or failing to give their answer to the nearest 100m as requested in the question.

Question 6

A well approached question overall, with a good range of available marks, this was a good discriminator.

For part (a) The sketch of $y = \dfrac{1}{2-x}$ proved to be troublesome to many students. Although most students drew a reciprocal type graph correctly, earning the first mark, it was often in the wrong position with the most common error of having the asymptote at $x = -2$, while an asymptote $y = \pm 2$ was also seen several times. Those who correctly positioned the graph generally added the y-intercept and $x = 2$, although some forgot to include one or both, and several cases of curves moving away from, or having too large a gap from, the asymptote were noted. The accuracy mark was therefore often lost although some leeway was given to curves that were essentially correct but had "flicks" at the ends.

Some were able to score the B mark for the correct asymptote and intercept even though the curve was incorrect (e.g. only one branch, though some more esoteric curves with these features correct were seen), but many incorrect responses (such as straight lines) failed to have an asymptote at all, despite the question making it clear there was one.

Many students were able to score all 4 marks in part (b)(i), but again, because this was a “show that” question, every stage of the solution had to be shown and had to be correct, and a significant portion jumped to quickly to the printed answer, and so loss of the last two marks was not uncommon. There were a variety of ways that a student lost marks here but the most common seen was incorrect cross multiplication resulting in $(kx - 4)(2 - x) = 0$ (meaning all marks in this part were lost) or omitting the ≥ 0 when applying the discriminant until the final line of the proof and instead working with $= 0$ or nothing at all (losing the final 2 marks). Although it would have been good to see a version $(kx - 4)(2 - x) = 1$ with terms collected and in the format of a quadratic equation, the first A mark was still awarded if it was clear the their a=... b =.... and c =.... were correct which was usually seen either stated or implied in their $b^2 - 4ac$ allowing access to the first A mark. However, most did realise the need to use the discriminant, and as long as a correct inequality was set up, the expansion and gathering of terms was usually shown, with only infrequent algebraic slips preventing the final A from being scored.

Part (b)(ii) was easily the most accessible part of the question with nearly all gaining the M, and many able to score the marks here even if they had scored no marks previously in the question, since the first M was essentially just for solving the stated quadratic in the question. The accuracy mark was a little more challenging as the correct region needed to be worked out, but most students were able to achieve this. The most common error was to select the inside region, while a few who identified the outside region also lost the mark for using x instead of k, while others gave $1 \geq k \geq 4$ which is incorrect as it describes a null set of values.

Question 7

This was a question of mixed performance, with again a number of blank responses noted, students willing to just pass over a topic they are not comfortable with. However, for those who made and attempt parts (a) and (b) were mostly completed well, with part (c) being less successfully attempted. It was remarkably common, however, to see students attempt this question using degrees instead of radians despite the repeated declarations that x is measured in radians in the question. These students would lose 2 of the 5 marks in (a) and (b) provided everything else was correct but should be advised to check the units required in such questions. Students also often wrote their answers in the rubric or provide a mix of responses in the rubric or on the following page meaning markers had to be careful to identify which answers were intended.

Most students scored well in part (a) and knew the coordinates of P and Q. The common errors were either using degrees instead of radians gaining just 1 out of 3 marks, or getting the sign of the x component wrong in P. Many students clearly did not look at the graph as their answers were not consistent with the given graph. Other notable errors were that many seem to work with $y = -4\cos 2x$ giving $(-\pi, -4)$ and $\left(\frac{3\pi}{4}, 0\right)$ as answer – which may also have been due to working in degrees and incorrectly converting. The coordinates were also quite often reversed and, in such cases, could score the first mark only. It was rarer for the -4 to be incorrect, but some did have just 4, or other incorrect values.

Part (b)(i) followed a similar theme. Those who worked in degrees in part (a) continued to do so but were allowed to score all marks in this part if there was nothing else amiss in the solution, which was the case for many. Identifying the value of k saw variable performance with $k = 15$ a common incorrect answer, with some students seemingly disregarding the ‘ $-$‘ in the equation of the curve (or exhibiting confusion over maximum/minimum points of a negative cos graph). But most did identifying the correct value of $k = 7$.

Again, most students (who made an attempt) scored the method mark for adding their value of k to the y coordinate of P, achieving the $y = 3$ (or follow through on their values), with errors with the x coordinate 2π more prevalent. That said, some were able to score this M from an incorrect answer to (a) provided they showed the correct relation between the two graphs. Some recovered fully to achieve the completely correct answer in part (ii). Again, coordinates were often reversed, allowing access to the method only.

Part (c) was by far the most challenging part of the question and a good discriminator, and many students did not know how to answer this part leaving it blank following their attempts at (a) and (b) and fully correct answers were very rare.

Also, many students did not use the given diagram at all to attempt to draw the straight line, ignoring the instruction in the question to use the diagram, so giving no access to marks. For those who did attempt to use the diagram, to score the M mark they needed to satisfy the four criteria as stated in the mark scheme. Most drew a line with a negative gradient, and it was usually passing through the point (0, 5), so these two criteria were often satisfied. However many either stated a number of solutions that was not consistent with their sketch, or did not mention the number of solutions at all, so the mark was not given. Others did not have a straight line drawn, so did not get over the first hurdle. These often attempt to group sketch a transformation of the given graph or had curves instead of lines.

For those who scored the M mark, a common error was to have drawn a line that did not intersect at the graph on the x axis, not working out the correct intersection point. Lines crossing three times with the graph were very common, though the consistent “3 solutions” was often given. Some drew a perfect line yet did not score the A as they gave no reason for their deduction that there would only be one root. Again a careful reading of questions is advised to make sure reasons are given when asked for.

Question 8

This question provided good access late in the paper with many able to score full marks here, and as such could easily have been set earlier in the paper. The methods required were demonstrated well by most students, and the “show that” was often well done in this case. There were many fully correct solutions to this question, and when not fully correct there was often only the final mark missing for a slip in calculating c.

However, it is notable that many students started by integrating f'(x) in part (a), often before realising it was not needed until part (b), but the question was marked as a whole to allow credit for the integration.

Success in part (a) depended on being able to identify the correct relation between the normal and the tangent gradient, and the majority were able to do this, often by implication but most did make a suitable clear statement. Only a very few used just the negative or just the reciprocal of the 24, but the most common error at this stage was simply using the $-\frac{1}{24}$ as the tangent gradient. Most who proceed to a suitable gradient were able to set up a suitable equation from which to derive k, and though some students did not simplify their f'(3) and jumped to the answer, most did give a suitable simplified equation before stating the printed answer. A few students attempted a verification method and those who did usually failed to provide a conclusion.

As noted above, there were also a number of students who integrated f'(x) initially, without taking stock of the question as a whole. Most of these recovered to a correct approach in (a) before using the integrated function in (b), but a few instead tried to derive k from the integrated function by setting it equal to the normal before stating the printed answer is if it followed the incorrect equation. Such attempts, naturally, gained no marks. These were able to score the first two marks of (b) even if they did not go on to attempt it, or use the integrated function in it.

Part (b) was again very well approached. The first two marks, for the integration were usually scored for correct work, even if seen in part (a), and the omission of $+c$ was condoned for this A mark. Even in cases where the value of k given in the question was not used, the first M was still commonly gained for the attempt at integration with k in place. It was good to see so many students with a firm grasp of calculus and the correct manipulation of constants and powers.

Though most include the constant of integration, several students omitted it and so could proceed no further. Those who attempted to find c generally went on to use a correct method by finding and substituting $(3, \frac{39}{8})$ into the equation to find c. The most common error was a slip in algebra finding the final calculated value for c. Other errors included obtaining an incorrect value for y at point P with no substitution into the correct equation for y seen often, or the use of zero instead, while some used the value $\frac{39}{8}$ as their $+ c$. While most students gave c as a fraction, many gave the value instead as the correct decimal value, but either was acceptable here as the decimal was fully accurate. A few students correctly found c but did not rewrite the full expression to gain the final A mark.

Question 9

This was another question which provided a good spread of marks and better access that some of the questions earlier in the paper. There was little evidence that students had run out of time on the paper and most were able to offer solutions for the whole question, although weaker students struggled with parts (a) and (c). Indeed, part (d) was answered well and sometimes all that was managed in the question.

Part (a), was probably the most challenging part, and it was not uncommon for this part of the question to be omitted with students simply moving straight into part (b). In some cases this part may have been overlooked entirely as many began part (b) labelled as part (a) with no prior work. Among those who did attempt many students were able to write down $x \geq -5$ immediately. Other students needed to determine the three roots of the cubic before concluding that −5 was the relevant critical value for x. Sometimes $x \leq -5$ was incorrectly stated or $x = -5$ stated alone. A number of students incorrectly gave the range using a strict inequality, others however stated '$x > -5$ or $x = -5$' which was condoned. In other cases, despite $x = -5$ being marked correctly on the graph, the range for $f(x) \geq 0$ was given as $x \geq 5$.

In part (b), the majority scored full marks.The most common approach was to multiply out the brackets before differentiating. Use of the product rule was seen occasionally usually to good effect with the correct answer following. Generally, the expansion of the brackets was completed successfully, and most students achieved the first mark for correctly obtain the x^3 term and the constant term. There were algebraic and/or numerical slips seen occasionally and sometimes quartics were somehow reached, but these were in the minority. The subsequent differentiation of the cubic was generally well done although again numerical errors were seen from time to time, for example $3x^3$ -> $6x^2$, was seen a few times and was the most common error in this part. Very rarely was integration was carried out rather than differentiation.

Part (c) proved more challenging to a significant number of students, with often just the first mark scored. The most common error was to not read the question carefully and assume that a line with gradient $f'(-4)$ passing through $R(-4, 84)$ was required to be found sometimes followed by work to find the intersection of this line with $f(x)$. Work along these lines could earn a maximum of 1 mark out of 4. Other students found the gradient of $f(x)$ at R but then were unsure of how to proceed and stopped work here, again earning 1 mark out of 4.

Of those students who correctly understood the need to find a second point on $f(x)$ with the same gradient as at R by setting $f'(x) = f'(-4)$, most were able to correctly establish a quadratic equation that needed to be solved and were able to proceed to find the x-coordinate of P, and achieve full marks. Some continued to find the corresponding y-coordinate which took valuable time unnecessarily. Earlier errors in either the expansion or differentiation of $f(x)$ meant that not all marks were accessible here but three out of four marks were usually available for correct work in (c) following errors in (b).

Part (d) was usually attempted and often the points were stated with no or little justification and mostly both coordinates were correctly given. The most common errors were (−7, 84) in (i) resulting from a horizontal translation in the wrong direction and (−4, 21) in (ii) resulting from a vertical stretch of scale factor ¼ rather than 4. Other students did not recognise that the transformation in (ii) was in one direction only so, for example, (−16, 336) and (−1, 336) were both seen from time to time. A small minority of students applied the transformation to point P from part (c) rather than to R, as required.

The answers were sometimes written in the question or at the bottom of an answer page after giving space in case they went back to try the other parts, but usually were easy to identify.

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