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Examiners' Report
Principal Examiner Feedback

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General

This paper proved to be a good test of candidates' ability on the WMA11 content and it was pleasing to see many candidates demonstrating what they had learned, and an increased confidence on the topic of radians. Overall, marks were available to candidates of all abilities and the parts of questions that proved to be the most challenging were 4(b), 7(a) and 9.

A significant number of candidates did not appear to follow the guidance within certain questions which indicate that the solutions relying (entirely) on calculator technology are not acceptable, or specific questions requiring all showing all stages of your working. This was evident on question 7 and on part 8(c). Trigonometric graphs and transformations are still found to be particularly challenging by candidates, however, as seen on question 3.

Report on individual questions

Question 1

This opening question was answered successfully by the majority of candidates. It was good to see that most candidates followed the instructions in the question and did give correct simplified answers.
In part (a) the vast majority of candidates differentiated the first 2 terms correctly and it was rare to see integration attempted. The final term caused difficulty to a significant minority, manipulating the last term $-\frac{3}{2x}$ (e.g. as $6x^{-1}$) prior to differentiating, thus losing the final accuracy marks.
In part (b), most candidates scored at least two marks. Common errors included calculation slips when substituting $x = 0.5$ into the equation for y or their equation for $\frac{\mathrm{d}y}{\mathrm{d}x}$, finding the equation of the tangent instead of the normal, or not giving the final answer in the required form. There were still candidates who did not give their answer as integer coefficients.

It should be noted that there was a number of responses which had mixed up the labelling of y and $\frac{\mathrm{d}y}{\mathrm{d}x}$ so candidates should be encouraged to make their working clear with correct notation used.

Question 2

This question was based on solving simultaneous equations set in the context of the height of a tree modelled by an equation involving indices. There were many fully correct, succinct solutions, although accuracy was very important in this question. The question overall was very accessible for the majority of candidates. Only a small minority misunderstood the concept of the question and therefore gained no marks at all.

In part (a), most candidates achieved the two correct simplified equations. For those who did not it was often a case of misreading the powers or occasionally even interchanging the H and t values. A few assumed the relationship was linear, setting out to find a "gradient" between the values given in the question. A number substituted correctly, but misread their own working, e.g. 2.4^3 was quite often converted to 5.76. Candidates who achieved the correct equations seemed to solve the simultaneous equations with ease, most opting for a full worked method. Rounding the $2.4^3 = 13.824$ to e.g. 13.8 or the $p = 0.364$ to e.g. 0.36 resulted in the final A mark being lost.

In part (b), those who successfully achieved the correct values of p and q in part (a) usually went on to achieve both marks. There was the occasional instance of poor rearrangement of the equation, dividing by p and then subtracting q, however most candidates were confident with making t the subject. A number incorrectly found $\frac{\sqrt{125-p}}{q}$, often simply through poor understanding of calculator protocols. Some candidates resulted in a negative square value inside their square root which could not score for this modelling question.

Question 3

Candidates found this question more challenging than expected with very few scoring full marks. However, most were able to find at least one coordinate correctly.

The majority found part (a) easier but poor understanding of graph transformations meant that many left part (b) unanswered and those who did were often incorrect. The most common mistakes were to have $x = 180$ instead of -180 in part (a) (i) and 0 instead of 360 in (b), mistakenly thinking 0 is positive. A few candidates left their answers in radians which was penalised as the question was clearly in degrees, whilst a smaller number reversed the coordinates thinking that -4 was the x value.
A small minority demonstrated a lack of understanding of trigonometric graphs and graph transformations and scored zero.

Question 4

This question involved a straight line intersecting a positive quadratic, with one intersection at the minimum point. Typically, most candidates were able to score 5 out of the 8 marks overall, however most found part (b) particularly challenging.

In part (a), candidates were required to find the equation of the straight line passing through two given points and was invariably found correctly. Most candidates were able to calculate the gradient of the line l correctly and proceeded to successfully find the y intercept to earn all three marks. Simultaneous equations to find the values of m and c were also commonly used. Errors, if made, were often sign errors when finding the gradient. Typically, candidates scored all three marks in this part.

In part (b) candidates were required to find the equation of the quadratic from the two given intersection points, and use had to be made of $(4, -5)$ being the minimum point, without which no marks could be scored. A pleasing number of candidates associated the equation of the curve and the turning point by writing $y = a(x-4)^2 - 5$. Unfortunately, the majority simply assumed that $a = 1$ and did not see the need to use $(-2, 13)$ thus losing the following two marks. Those who did not assume $a = 1$ solved quickly to find the correct equation, gaining all three marks. Other ways of using the minimum point were seen, usually by using $x = -\frac{b}{2a}$, giving $-b = 8a$. Some differentiated a general quadratic to obtain $\frac{\mathrm{d}y}{\mathrm{d}x} = 2ax + b$, and used $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ at $x = 4$. The symmetry property around the minimum point to find another point $(10, 13)$ was used quite rarely. Many candidates who attempted way 2 on the mark scheme started out with $y = ax^2 + bx + c$ and could proceed only as far as two simultaneous equations containing three unknowns. These candidates did not appreciate that the turning point needed to be used by either differentiating and setting $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ or using $-\frac{b}{2a} = 4$ in order to find the third equation. Those candidates who considered $y = ax^2 + bx + c$ to be the equation rarely gained any marks.

Part (c) required identifying a shaded region between the quadratic and the line using inequalities. Many candidates gained the M mark for two inequalities, using their line from (a) and their quadratic from (b), provided it was a positive quadratic. Very few candidates scored both marks in this question, the most common error being to omit $x < -2$ (or a variation of this) as one of the inequalities. Occasionally a candidate would use "R" instead of y in the inequalities which was not accepted. Some others did not reference y at all, making the "line < curve" into an inequality in x.

Question 5

This question was generally answered well, with many candidates quoting formulae prior to use and setting out their work in a structured way. Successful candidates read the question and understood that the obtuse angle was required and engaged with the diagram, however far too many missed this crucial piece of information. Asa result, many candidates only used the acute angle thus only able to score 6 out of a possible 9 marks.

In part (a), this required the use of the sine rule and most candidates successfully found the acute angle. Many candidates did not go on to find the obtuse angle though some that did, did not give the angle to the required accuracy. Some candidates worked in degrees instead and converted to radians at the end, but this often lost some accuracy. Weaker candidates mixed degrees and radians, and several forgot to find $\sin^{-1}(0.973)$. Some candidates attempted to use the cosine rule, despite only knowing two sides of the triangle.

In part (b), the majority of candidates scored at least 1 mark by applying the correct formula with an allowable angle. Most candidates used the correct followed through angle in their formula, but some used one of the other allowable angles. A minority of candidates used an incorrect formula or attempted to use an angle in degrees instead of radians with $r\theta$. Weaker candidates used $\frac{1}{2}r^2\theta$ for finding the arc length.

In part (c), most candidates scored at least one mark, usually for the area of the sector with an allowable angle. Many candidates who found an acute angle in part (a) correctly followed through their work. Many candidates made errors in the calculation of the area of the triangle by not correctly matching up sides and angles or not identifying the correct triangle, it was not unusual to see $\frac{1}{2}\times 6^2 \times \sin(\text{allowable angle})$ or assuming that $OD = 14$ and using $\frac{1}{2}\times 14^2 \times \sin(0.43)$. Several candidates did make unnecessary calculations by using the cosine rule to find *OD*, although they generally were able to proceed to full marks. Some candidates who rounded intermediate answers lost the final mark for accuracy.

Question 6

Candidates performed quite well on this question, with parts (a) and (c) being particularly well answered.
In part (a), almost all candidates achieved full marks for this part of the question. Of those who did not, it was usually for drawing the graph of $\frac{1}{x}$. There were a few candidates who completely failed to sketch the correct graph, with some linear graphs seen and there were even a few attempts where they tried to plot the coordinates using a table of values. Candidates should continue to be reminded about the need to ensure the key features are indicated on a sketch and the intention is clear. In some cases, it was ambiguous as to whether some sketches actually meant to have a maximum or a minimum on parts of the curve, rather than demonstrating asymptotic behaviour, when it was probably down to poor sketching.
Candidates clearly found part (b) more challenging, however most candidates did achieve at least the first mark for translating the graph upwards. A few candidates did not attempt to state the equation of the asymptote at all whilst some just labelled 'k' on the y-axis or on the line, therefore not stating the desired equation. The x intercept seemed to prove most challenging with a fair number of candidate either missing it out or labelling the intercept as 'k'. Of those who found the correct intercept a few left their answer as $\frac{k}{k}$, which was condoned.
A minority of candidates missed part (c) out completely. Most of the remainder made a good attempt and achieved a high proportion of the marks. Most were able to reach a 3-term quadratic equation and to identify the need to look at the discriminant. A few weak candidates obtained a 2-term quadratic by not multiplying all the terms by the x from the $\frac{k}{x}$ term, resulting in no marks for this part. A number made mistakes in the signs of terms when transferring them from one side of the equation to the other.

It was a fairly even split in terms of obtaining the critical values using the calculator method versus showing evidence of solving (which was usually done via the quadratic formula). Once achieving the correct critical values most candidates were then successful in identifying the correct region and stating a correct inequality. Only a very small number of candidates used the variable 'x' in place of 'k' and similarly, very few gave the final answer in decimal form.

Question 7

This question was a good discriminator between candidates. However, there is a significant number who still need to understand that if a question states that solutions relying on calculator technology are not acceptable then they should treat the question as a non-calculator question. Marks are awarded for solving a 3-term quadratic by factorising, completing the square or quadratic formula; in part (b) marks were awarded for correct manipulation of indices.

In part (a) a significant minority of candidates lost all marks because they did not show working when solving their quadratic equation, presumably finding solutions from their calculators. It was not unusual to see candidates squaring individual terms $4x^2 - 9x + 25 = 81$ set to 0 and proceed to solve their quadratic, scoring zero marks. This is a major misconception at this level. A large number attempted to rearrange to $3\sqrt{x} = ...$ and then square both sides correctly, although this method tended to lead to more algebraic errors. The most successful candidates were generally those who replaced $x^{\frac{1}{2}}$ by another variable. Unfortunately, the variable x was often used again, which led to some of them forgetting to square the final answer and losing 2 marks. Most candidates did choose to factorise and for those who squared both sides they successfully went on to solve using the quadratic formula as the preferred method.

Many candidates who used a sound method lost the final mark by failing to reject 4 as a solution; candidates should ensure that they take note of any constraints on the domain of a given function and take time to check against their solutions. It was also noted that there was a significant minority of candidates who did no credible work for this part. Some candidates differentiated the function or substituted 9 into the function. Others did not know where to start with given equation.

In part (b), many candidates scored full marks, even if they had scored no marks in part (a). Common errors included errors or slips when differentiating or manipulating powers. Some candidates solved $f'(x) = 6$ instead or integrated instead of differentiating. Some candidates calculated $f''(6)$ instead of solving the required equation. Most candidates were able to show enough steps when solving $f''(x) = 6$ the preferred method was to go from $x^{-\frac{3}{2}} = 8$ to $x = {}^{-\frac{3}{2}}\sqrt{8}$ hence $x = \frac{1}{4}$ which scored full marks on this occasion. This should not be taken to be the minimum acceptable in future, however, and candidates should be encouraged to show more stages of their working to ensure that full marks can be awarded, particularly where it states that the use of a calculator is not acceptable. For example, in this question the intermediate steps of square rooting, cubing and finding the reciprocal could be shown to demonstrate a full method and to evidence that a calculator has not been used.

Question 8

This was a good discriminating question. However, it was rare for full marks to be achieved, with a large number struggling with part (a).

Part (a) was rarely answered correctly with $x > 4$. Far too many either failed to answer or left other inequalities in their solution and most candidates found the intercepts but were unable to identify the required inequality.

In part (b), candidates usually scored full marks. A small minority tried to square the bracket by squaring the two terms and losing the x terms, hence forfeiting all 3 marks. The most common errors were slips in signs or powers. It was pleasing, however, to see the vast majority successfully multiply out the three brackets and achieve the correct answer.

Part (c) discriminated candidates well, with good candidates gaining at least 3 marks. However, too many relied solely on calculators which was prohibited by the wording of the question. In particular, there was a large number who just proceeded from the cubic and either used the solver function or possibly used a graphical facility to determine the roots. Those that had a fully correct part (b) often achieved a correct answer in part (c), but too many failed to show the quadratic equation after factorising out the x, thus losing marks. Most who found roots were able to subtract them to attempt the distance PQ. A small number attempted to use the distance formula unnecessarily as both the y values were the same. There were still some solutions, however, which had incorrect methods seen, which were penalised so candidates should always be reminded to check their solutions are correctly presented in parts such as this.

Question 9

This question was one of the most challenging questions on the paper for candidates. It was extremely rare for full marks to be scored, although nearly all candidates were able to pick up at least some of the marks. There were a number of blank or partly completed solutions for this question, which may have been due to time, or more likely the level of difficulty due to it being the final one on the paper.

Part (i) was similar to questions which have been asked previously, requiring integration of a rational function. In this case, it required the squaring of a bracket and division by $\sqrt{x}$ in order to have access to the first mark for a correct index number. Some candidates mistakenly multiplied by $\sqrt{x}$ hence gaining no credit in part (i) and some candidates still incorrectly attempted to integrate the numerator and denominator separately. A significant number managed to manipulate the terms to get at least two and then integrated correctly. However, issues with the fractional powers and division by fractions led to many errors. This part was answered well by confident candidates and it was pleasing to see most candidates remember the constant of integration.

Part (ii) was independent of (i) and was one of the most challenging parts on the paper. Unfortunately, too many candidates tried to use their earlier answers by using the point $(3, -2)$ to find c. Others were unsure how to proceed with the bullet points of information and made no attempt. Those that recognised the notation for gradient were able to integrate correctly and use the required point and intercept to form an appropriate equation. Many candidates stopped at this point. A second equation was needed to be found using point P and the given gradient and many could not use -8 as the y intercept together with the point $(3, -2)$ to get this second equation. Those that traversed this far were able to solve the simultaneous equations and form a cubic equation for the curve, although errors were frequent in doing this, so even then it was rare for candidates to score full marks.

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