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Examiners' Report
Principal Examiner Feedback

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General

This paper had many accessible questions, and it was pleasing to see candidates were able to make attempts at all of the questions. There were many familiar types of questions, so candidates should have felt prepared had they completed past papers. There were some questions which candidates found particularly challenging, namely Questions 4(i)(b), 4(ii)(a), 5(c), 9(c)(ii) and (iii). The paper provided good discrimination across all candidates and all abilities should have been able to demonstrate what they could do. It should be noted, however, that there are the warnings at the start of some questions stressing the importance of showing all stages of working, as well as the rubric at the front of the paper stating that sufficient working should be shown. This was seen on Question 2(a) and 5(b). Some candidates still do not provide evidence of a full method, which may result in not being awarded all of the available marks such as in Question 7(b).

Report on individual questions

Question 1

This question was an accessible integration question which involved changing two of the terms into index notation which could then be integrated.

Many candidates successfully answered this question. If a candidate lost marks, generally it was only the last one which was either for forgetting the "+ c" or making an error with the third term where $\frac{2}{5x^3}$ was incorrectly converted when using index notation.

Question 2

This question tested surds within the context of straight-line graphs. The question included a calculator warning and a requirement that all stages of the working should be shown. The aim of the question was to test the rationalising of a surd in part (a) and then in part (b) to use the negative reciprocal to work out the gradient of a perpendicular line.

In part (a), a high proportion of candidates lost marks due to not clearly showing the rationalising of the denominator. Many will have put the whole calculation into the calculator and will have achieved the final answer from there, without showing the rationalising. Candidates that used simultaneous equations to find the gradient tended to score no marks, as they used their calculator to solve them, despite the calculator warnings.

Part (b) was generally more successfully answered and also enabled candidates to score two marks even from an incorrect part (a). A large number of candidates used $m = \frac{1}{9}$ and then applied the negative reciprocal to this, presumably because the last thing they wrote in (a) was $p = \frac{1}{9}$, rather than understanding that the entire $p\sqrt{3}$ was the original gradient. A small number of candidates used the wrong pair of coordinates, but this was often a high scoring part.

Question 3

This question tested solving simultaneous equations in a contextual scenario. Most candidates attempted this question, with many earning all five marks.

In part (a), most candidates successfully formed simultaneous equations in *a* and *b* and then proceeded to find values for *a* and *b*. The most common mistake was to use 58000 and 65000 in the calculations, rather than 58 and 65. A handful of candidates used 5.8 and 6.5. Both of these mistakes meant that no marks were available in this part, although they could still score full marks in part (b). A few candidates forgot to square *P* i.e. used $P = a + bt^3$, which also resulted in no marks due to simplifying the problem. Quite a few candidates seemed to just stop before obtaining values for both *a* and *b*, apparently unable to solve the simultaneous equations.

In part (b), most candidates were able to get to the answer of 15.9 and gained both marks. This included those who initially used 58000 and 65000 and those who used 5.8 and 6.5. Most candidates substituted their *a* and *b* values into the formula as a first step, rather than rearrange the formula and then substitute in the values. Some candidates lost marks for incorrect indices. For example, there were some misreads of the question, with some candidates reading the power of 3 as a power of 2. If this misread was consistent throughout the response, method marks could still be gained, although in some responses this misread only occurred in part (b). The values of *a* and/or *b* obtained in part (a) were not necessarily used in (b). Sometimes 3364 (58^2) or 4225 (65^2) were used for the *a* value, for example.

There were a significant number who had made errors in calculating *a* and *b* and so could only obtain the method mark for substituting these values into the correct equation and finding *T*. In addition, gaining all 3 marks in part (a) and the method mark in part (b) was not a guarantee of the final mark. Errors using a calculator, or mistakes in the rearranging were often the reason here. Some managed to get the correct value of T^3, but then square rooted to give an incorrect answer, despite having a power of 3 throughout their working. Rounding of the final answer presented a problem for some; in some cases, an answer of 16 was given without a more accurate value. These responses could not get the answer mark in part (b). If they had written the answer as 15.9... beforehand, then the mark was still available due to applying isw.

Question 4

This question had quite a few parts to it and really tested a deep understanding of indices in a variety of ways. Part (i) required candidates to use of laws of indices to rewrite expressions in terms of *a* and *x* in terms of *a* and *y* (where $y = a^x$). In part (ii), candidates were required to use index laws to rewrite an equation in *t* into a given quadratic in *p* where $p = 9^t$, hence solving the original equation in *t*.

Part (a) was generally answered correctly, with candidates recognising that the index could be separated to give $a^3 \times a^1$ and then simplified to ay^3. A few left in the multiplication sign (or a dot) and forfeited the mark. A common error was to write $a^{3x} + a^1$ indicating a fundamental misunderstanding of the addition law of indices.

Candidates typically found part (b) more challenging. The 5 on the numerator and 3^{-2} on the denominator were often eventually combined to give 45, but some struggled to process the indices correctly with $\frac{5}{3}$ or $\frac{5}{9}$ often being seen. A large number of errors also came from dealing with the "3" which was sometimes attached to both the a^1 and a^x terms and so "cancelled out". On the whole, most candidates made some progress in simplifying $\left(a^{1-x}\right)^{-2}$, and obtained the second mark, but this was often corrupted at a later stage. A wide range of mark patterns was seen for this question part, but generally scores were very low.

In part (ii)(a), many candidates struggled to process the 3^{4t+2} with $9^{4t\dots}$ being seen fairly frequently. The most common correct process was proceeding directly to $9^{2t} \times 9$, although an array of correct methods was seen. A few cautious candidates began their solution by factorising the $4t$ to $2 \times 2t$ and proceeded correctly to the given equation in several steps. Of those who expanded the bracket after successfully dealing with the power "$4t + 2$", a few neglected to show an intermediate step before the given answer and did not gain the accuracy mark.

Part (b) was generally well attempted with candidates who had failed to score earlier in the question achieving at least one mark. Quite a number used the formula or factorised to solve the quadratic, whilst others did not show a method and found their solution directly from a calculator. Candidates should still pay careful attention to the warnings at the start of a question as this approach could have been penalised on a different occasion. A significant number of responses did not go any further than finding solutions to the quadratic in *p*; many of these candidates would benefit from being reminded to observe the variable of the equation they have been asked to solve, as well as the number of marks for the question part. Either of these observations should have prompted these candidates to continue with an attempt to find a value for *t*. For those candidates who did proceed to solve for values of *t*, some showed visible evidence of using logarithms whilst others appeared to work intuitively with the powers. Occasionally it was deemed that one of the values for *p* would not lead to a value for *t*.

Question 5

This question tested differentiation and solving a hidden quadratic to find an unknown constant in the linear equation. Candidates were usually able to score in part (a), although a lack of method shown or an incorrect approach meant that many marks were lost in the later parts.

In part (a), the majority of candidates who attempted this part managed to score both marks. Almost all candidates obtained $12x^2$, but it was more common to fail to obtain $2x^{-2}$. For example, there were a few responses where $\frac{2}{x}$ was differentiated to $2x$ or just 2. In the occasional response the candidate attempted to integrate, but these were rare. There were a few instances of inclusion of "+ *c*" or + 9 as a third term. The question was quite often abandoned after part (a).

Quite a few candidates did not attempt part (b). Many candidates did not seem to make the connection between the derivative and the gradient of the tangent, or did not understand that the gradient of the tangent was needed at all. A significant number of responses began with an incorrect approach such as setting the derivative equal to the equation of the line, or setting the curve equal to the line, which would be a valid approach for part (c), but not part (b). Also observed was setting their part (a) equal to $-5x$, which some candidates thought was the gradient of the line. Often with these approaches, the algebra led nowhere. For example, these incorrect equations were sometimes followed by an attempt to use the discriminant (in part (b) or part (c)) to find a value for *k*. Sometimes the correct given answer would appear at the end of the working with no correct justification. However, there were also a good number of correct responses with an intermediate stage of working before the final answer as required by the mark scheme. Some candidates, however, did lose the last mark by setting their answer to part (a) = -5 and then writing down the given answer, with no intermediate line. This part was sometimes left out, with these candidates attempting parts (a) and (c) only. Some candidates, when seeing the quartic equation in the question, automatically attempted to solve it, failing to understand that they were required to prove it.

Those who missed out part (b) often attempted part (c). Many of the incorrect approaches outlined above for part (b) were also seen in part (c). The first mark was given for demonstrating a correct method for solving the quartic to get solutions for *x*. Candidates used the full range of methods to solve the quartic. Substituting a variable for x^2 to obtain a quadratic and then factorising was the most common, although the use of the quadratic formula for either the quartic or the quadratic (from a substitution) were also very common. Many candidates gave solutions to the quartic without showing the required working, losing the first M mark. Another common error was to write down an incorrect factorisation of the quartic, e.g. $\left(x^2+\frac{1}{4}\right)\left(x^2-\frac{1}{4}\right)$, often finding the solutions from the calculator and attempting to write down the factorisation based on the roots. Substitution was very popular as many preferred to solve a quadratic, rather than a quartic equation. This caused problems for some as they then forgot (or did not realise that they needed) to take the square root of their positive root. Since a significant number of candidates failed to gain the first method mark, losing the first and last marks in this part was common.

There were a number of solutions in which $\frac{1}{4}$ was used as the value of x, for which no marks could be given as they had missed out the step of taking the square root of this value. Incorrect factorisation (where the signs were switched) sometimes led to $x = \sqrt{\frac{2}{3}}$ and the other answer $x = \sqrt{-\frac{1}{4}}$ was rejected. Having a value for x, some candidates substituted that straight into $y = k - 5x$, gaining no more marks. Some tried to substitute their x value into the gradient found in part (a). For the second method mark, there were numerous examples to substitute a negative value of x (in addition to the positive value) to produce an alternative value for k despite "$x > 0$" in the wording of the question. This was a fairly common way for a candidate to lose the final A mark. If $x = \frac{1}{2}$ was obtained, the value $y = \frac{27}{2}$ appeared quite often without working. The substitution of x and y values into $y = k - 5x$ for candidates who got this far, was usually handled successfully, to get $k = 16$. The alternative method (setting the equation of the curve equal to the equation of the line and substituting in $x = \frac{1}{2}$) was not widely used but often demonstrated a neater and more succinct method to solving the problem.

Question 6

This question was very accessible to candidates with a good number achieving full marks and only very few failing to score any marks. The vast majority scored well.

Part (a) produced many encouraging responses, with a significantly high proportion of candidates being able to use $f'(4) = 7$ to prove that $4a + b = 24$. Most candidates used a direct substitution in the given form of $f'(x)$, but others expressed $f'(x)$ as the sum of three terms before substituting, thereby lengthening their solution and more likely to lead to errors even though the answer was given. Apart from mistakes dealing with the indices the most common errors were equating $f'(4) = -5$ (the y coordinate of P) or equating to zero and fudging the solution. A small proportion of candidates failed to give any intermediate steps between their initial substitution and the given result, thereby losing the 2nd mark.

In part (b), most candidates recognised that they had to solve two linear simultaneous equations for a and b. The vast majority did so successfully, but others made a simple arithmetical error in the solution. A further small proportion of candidates failed to recognise that they had been provided with two simultaneous equations to solve. Expressing $f'(x)$ as the sum of three terms with fractional indices and the subsequent integration was done extremely well, with relatively few numerical errors. A small proportion took the 4 into the numerator by mistake and hence lost a number of marks. Some candidates forgot to include a constant of integration and were therefore unable to obtain the final 2 marks in part (b). A small number of candidates failed to show the relevant steps in working that was required by the question thus losing marks.

In part (c), the translation of 3 units in the positive x-direction was detected by a significant majority of candidates, although some candidates failed to attempt it, and $Q(1, -5)$ was occasionally seen.

Question 7

This question tested sketching a reciprocal graph followed by use of the discriminant when working with graphs which intersect.

In part (a), the quality of sketches was generally better than in previous sessions. However, few candidates achieved all three marks available for this part of the question. Common errors included misrepresenting the horizontal asymptote as a vertical line even when it had been correctly identified as $y = -k$. When the asymptote had been correctly drawn it was often labelled simply as $-k$ or $y = k$ even though it was drawn below the x-axis. The labelling of the point where the curve intersects the x-axis was often omitted or mistakenly labelled as $\frac{k}{2}$ or even $\frac{2}{x-k}$. Overall, the graphs sketched were typically exponential, although some cases were seen of straight lines, parabolas or cubic functions being sketched.

Part (b) was generally answered well, even by candidates who had struggled with part (a). Almost all candidates who attempted part (b) successfully set the two equations equal to each other, but errors arose when multiplying through by x, preventing some candidates from securing the first method mark. The candidates who correctly formed the quadratic equation nearly always earned the second method mark for attempting the discriminant. A significant number of candidates, however, either simply stated the two roots of the quadratic equation or provided the inside region instead of the correct solution. Those who sketched the quadratic function often identified the correct solution in terms of the outside region, but this was sometimes given as $18 < k < 2$. Only a few candidates noted $k > 0$ in their final answer, although this was not strictly required.

Question 8

This question testing radians and trigonometry was attempted by most candidates. There were very few blank responses, and most attempts were successful in achieving some of the available marks. The angles were given in radians and the majority of candidates worked in radians throughout; those who worked in degrees often struggled to obtain correct answers. There were a number of potential pitfalls which allowed the more observant candidates to demonstrate their skills.

Part (a) required candidates to find an obtuse angle in a non-right-angled triangle. Although there were several possible routes, the majority of candidates used the sine rule. Unfortunately, a large proportion of candidates either did not notice that the question requested an obtuse angle, or did not recognise that the angle they had found was not obtuse. This oversight resulted in a loss of accuracy marks throughout the remaining parts of the question. Centres could use this to exemplify the need to pay careful attention to detail when the answer to an early part of a question will be used throughout the rest of the question. Other errors included using 2π as the sum of the angles in a triangle, using $\frac{\pi}{6}$ rather than $\sin\left(\frac{\pi}{6}\right)$ and using the sides/angles in the incorrect places. Some candidates worked with alternate methods such as using the cosine rule, solving the resulting quadratic equation to find length *OA* and then using sine rule or cosine rule to find angle *OAB*. Some even found the area and then used the area expression again to find the required angle. Candidates who used one of these alternate methods proved themselves to be confident and efficient in such methods, or very quickly stopped working. On occasion, candidates did not give their answer to the required degree of accuracy or truncated rather than rounding.

Part (b) required candidates to find the area of a triangle. Most candidates attempted to use the trigonometric formula for the area of a triangle although $\frac{1}{2}ab\theta$ and $\frac{1}{2}r^2\theta$ were both seen on occasion. Those using a correct formula often scored the method mark, but some did not recognise the need to find the included angle (*OBA*), instead using $\frac{\pi}{6}$ or their angle from part (a) – both incorrect methods that scored no marks. Candidates who used one of the longer alternative methods in (a) sometimes used their calculated value for *OA* to find the area correctly using *OB*, *OA* and $\frac{\pi}{6}$. Candidates who failed to identify the obtuse angle in (a) were unable to score the accuracy mark in this part of the question. A number of candidates used the given value from part (c) to work backwards to find the area. While it is to be encouraged that candidates use given answers to check their work, they were not eligible to score full marks in this section. As a general rule, it is not acceptable to use information given later in the question to work backwards as that is not meeting the demand of the question where "given that…." information is provided and needs to be used.

In part (c), many candidates used a correct method, multiplying their area from (b) by $\frac{3}{2}$ and setting it equal to $\frac{1}{2}\times 3.4^2 \times \theta$. Some candidates incorrectly interpreted the ratio statement, multiplying by $\frac{3}{5}$, $\frac{2}{3}$ or $\frac{2}{5}$. Some candidates simply substituted their answer to (b), scoring no marks. Poor notation was seen, with some candidates working in terms of *r* and never explicitly using 3.4 in their work – insufficient for a 'show that' question. Using the formula for the area of a triangle rather than a sector was a fairly common error. Candidates who were working with an acute angle from part (a) did not reach the correct answer. Some of the more astute candidates worked backwards from the given answer in an attempt to find their error but few went back as far as part (a) to correct their error.

Part (d) required candidates to find the perimeter of a composite shape formed from a sector and a triangle. Some candidates made no attempt at this part of the question, potentially put off because they had not reached the given answer in part (c). Most attempts included a correct method to find the arc length using the given information thus scoring an easy mark. Many candidates also used a correct method to find the length of *OA*; the cosine rule, sine rule and area formula were all commonly seen. Some of the methods did not require use of the angle found in part (a) thus allowing candidates with an incorrect value for the angle to score full marks. The final method mark was for a correct overall strategy for finding the perimeter of the shape. A surprising number of candidates made the error of including the length of side *OB*, an internal side, when summing the lengths to find the perimeter – an incorrect method which resulted in the loss of this method mark. Candidates who were working with an acute angle from part (a) were not eligible to score this mark.

Question 9

This was a very structured question which tested basic techniques. The question was very successful in differentiating the ability of candidates as only the most proficient candidates gained full marks with weaker candidates mostly gaining marks on parts (a) and (b) and generally the first B in (d).

A few candidates made no attempt at all or stopped part way through the question which may have simply been due to this being the final question of the paper.

In part (a), the majority of candidates evidenced an understanding of the method required to complete the square with many successfully achieving the correct result. Where marks were lost this was often due to not dealing with the negative coefficient of x^2 correctly or basic arithmetic errors in calculating the constant. A surprising number of candidates benefited from the instruction to "isw" often achieving a correct answer and then rearranging incorrectly.

In part (b), most candidates demonstrated an understanding of how to obtain the coordinates of the maximum point directly from their completed square form in part (a) and did so correctly. However, a surprising number of candidates failed to acknowledge that part (a) was designed to support their answer to part (b) and instead found the coordinates of the turning point via other methods such as differentiation. A very small minority did use part (a) but not effectively, instead they took the x coordinate of 3 and used the equation of C_1 to find the y coordinate of P. Both marks were available if candidates had an incorrect P but had followed through from their part (a), stating P as (their –"c", their "a"). This follow through was awarded numerous times however sign errors occasionally prevented the second B1ft from being given. Very few candidates made errors here but those that did either had an incorrect sign on the x coordinate, as mentioned above, placed the x and y coordinates in the wrong places e.g. $\left(\frac{9}{4}, 3\right)$ or put $x = 0$ into their part (a).

Part (c) really discriminated between the more able, well-prepared candidates to those less ready.

In part (c)(i), many stated the x coordinate of B to be $\frac{9}{2}$ and achieved this mark. Some candidates, having solved the quadratic, left both answers $\frac{3}{2}$ and $\frac{9}{2}$; this was not acceptable if the x coordinate for *B* was not identified. Nor was it acceptable to leave the answer as $3+\sqrt{\frac{9}{4}}$ though this was seldom seen. Other candidates were clearly confused and gave answers such as 270, $\frac{9}{2}\pi$, $\frac{1}{40\pi}$ etc.

In part (c)(ii), a reasonable number of candidates were able to use their knowledge of a cosine curve and solve $\frac{3}{2}=k\frac{\pi}{2}$ using A or $\frac{9}{2}=k\frac{3\pi}{2}$ using B to obtain $k=\frac{\pi}{3}$. Errors that suggested some understanding but with careless application were $k=60, \frac{3}{\pi}, \frac{1}{3}$. Other candidates tried to equate the equations of the two curves and obtained answers such as 0.867 or 85.5. An incorrect value of *k* resulted in the final mark of part (d) also being lost.

Part (c)(iii) was the least successful part so far. Many candidates omitted it altogether. A significantly small number of candidates knew that the period was the horizontal distance for one complete cycle of the cosine curve. A deeper understanding of trigonometric curves would allow candidates to have realised a complete cycle would be double the horizontal distance between *A* and *B.* Although this would still require the roots to be correct; they generally were correct. Errors that did suggest a vague understanding were $3,\ 0 \leqslant x \leqslant 6,\ 6\pi$ and even $\frac{360}{k}$. Interestingly, $-1 \leqslant y \leqslant 1$ was seen on a few occasions suggesting a lack of understanding in the difference between range and period.

Only the most able mathematicians achieved full marks in part (d), as earlier errors in finding the coordinate of *P, B* or the value of *k*, which were common, resulted in a loss of at least 1 or 2 marks. The most commonly achieved mark in this part was the first B1ft owing to the generous acceptance of "in terms of *k*", the follow through and only requiring two of the equations which were given. A number of candidates did not make any attempt at the equation of the line. However, those that did, evidenced a strong understanding and executed a successful method to use their *P* and *B* to find the equation of the line. The A mark generally hinged on previous answers as this was not a ft. These candidates predominantly then went on to state three inequalities to describe region *R*. Again, the success of this hinged on previous values. Further to the required inequalities, a number of candidates included the range of *x* values, generally $1.5 < x < 4.5$. Although this was not necessary, it was accepted providing it did not restrict the domain incorrectly. Errors in the inequality itself were rare and only a very small number of candidates used *R* rather than *y* in their inequalities. Another, more fundamental error, was by the very few candidates who did not appreciate the demand of the question and instead attempted to integrate the quadratic expression in an attempt to find the area instead.

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