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International Advanced Level in Pure Mathematics P1

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General Comments

This paper proved to be a fair test of learner knowledge and understanding. There were many accessible marks available to all learners as well as a few more challenging question parts answered well in stronger responses.

Question 1

The opening question on surds was a reasonable source of marks for most learners.

Part (a) required the use of Pythagoras to find the length of a right-angled isosceles triangle whose equal side lengths were 2*x*. A very small number of responses used trigonometry and were often incorrect. There were many cases of missing brackets i.e., $\sqrt{2x^2+2x^2}$, which lead to the conclusion that the hypotenuse was also of length 2*x*. Simplest form was required so $\sqrt{8x^2}$ did not score the accuracy mark. A small number of learners wrote $\sqrt{8x}$.

The first mark in part (b) required the perimeters of the two triangles to be equated and it was unusual to not be awarding this mark. However, a few responses equated a pair of sides or attempted to equate areas. Most appreciated they then had to solve for *x* and the next mark for isolating *x* was usually scored, but there were cases of incorrect algebra. Those who had demonstrated an expression of the correct form then needed to show how the expression was rationalised and this was often missing. Although there were many completely correct solutions, 11100 was also very common when learners relied on their calculators.

Some attempted to square and often did not use a^2+b^2 for $(a+b)^2$. Those who obtained a correct equation invariably solved it validly but choosing this route

meant that the solving method had to be explicit. Some did not reject the negative "solution" introduced by the squaring.

Advice for teachers and learners:

It is expected that learners should be very familiar with the word "perimeter".

Expressions of the form $\sqrt{a}x$ need to be written carefully.

This question, like many others on this paper, had a warning to learners that their solution must not rely on calculator technology. In such cases, working is required to demonstrate how the given problem is solved. A significant number of learners did not gain marks with regard to this point.

Question 2

This question on simple algebraic processing, differentiation and quadratic inequalities saw very good scoring, with plenty of fully correct solutions. This question also had a calculator warning.

Most knew that in part (a), the expression had to be expanded and this was usually performed correctly. The method of differentiating terms of the form kx^n was also well-recalled and it was unusual to see errors here.

The overwhelming majority formed a quadratic inequality although some automatically solved $3x^2 + 2x - 6 \geqslant 0$ instead of the required $3x^2 + 2x - 6 \geqslant 2$. However, the responses that wrote answers down instead of showing how they solved the problem were not able to gain marks. There was mixed success in choosing the outside region. Although ISW was applied here , sometimes a correct answer was followed by an incorrect modification of the region.

Advice for teachers and learners:

Sketch graphs are a very useful way of choosing the correct region in these situations. Where they were used, learners were almost always correct.

Question 3

This was designed to be a relatively accessible question but it showed a mixed response. A small number did not show multiplication through by y^2 which sometimes lead to all manner of equations including linear ones. Some did not carry the multiplication out correctly since a term was missing. Those that did obtain a quadratic in y^2 invariably made progress although again a valid non-calculator method was required by the question. Occasionally roots were mislabelled. Some sensibly made a substitution of e.g., $y^2 = x$ but a small number did not return to *y* afterwards and so did not square root. A common error was to forget the negative solution after square rooting.

Advice for teachers and learners:

Solving quadratics in x^2, x^3 and so on is expected in this module.

Question 4

There were many fully correct responses to this question on equations of straight lines and their perpendiculars, but there were also many weaker responses.

In part (a), it was common to see a correct numerical expression for the gradient of *PQ*. However there were sign errors and cases where $\frac{x_1 - x_2}{y_1 - y_2}$ or $\frac{y_1 + y_2}{x_1 + x_2}$ was used instead of $\frac{y_1 - y_2}{x_1 - x_2}$.

Most were able to apply a correct straight-line method although occasionally coordinates were not accurate. Some errors in the subsequent processing were seen, particularly with those using a $y = mx + c$ approach. However, the most common error was seen in responses that did not employ integer coefficients.

Various methods were attempted for part (b). The most popular was to obtain the negative reciprocal of the gradient of *PQ* and equate this to the gradient of *PR*. Most attempts via this method were usually correct and often led to full marks. Others formed simultaneous equations - these were usually correct although marks were sometimes not able to be awarded if the answer was just written down immediately afterwards, since the question required no reliance on calculator technology. Attempts at using Pythagoras were also seen. These were more mixed due to algebraic errors. Particularly noticeable was the misconception that $\sqrt{a^2 + b^2}$ could be replaced by $a + b$.

Advice for teachers and learners:

Many learners are not awarded full marks by not giving their final answer in the required form - this question required "=0" and integer coefficients for the line equation.

Learners who chose to approach the problem with $y = mx + c$ rather than $y - y_1 = m(x - x_1)$ seem more prone to error in most questions like this.

Question 5

This question on integration was a good source of marks for the majority of learners.

Almost all knew that the algebraic fraction had to be dealt with first and most were able to process it correctly, although there were a few errors such as

multiplying through by $2x^{-2}$ instead of $\frac{1}{2}x^{-2}$. The method of integrating kx^n was well recalled, although a common error seen was multiplication of 2 by $-\frac{1}{2}$ so that $2x^{-\frac{3}{2}} \rightarrow -x^{-\frac{1}{2}}$ instead of $-4x^{-\frac{1}{2}}$. Occasionally, indices were reduced by 1 instead of increased by 1. Some weaker responses involved separately integrating the numerator and denominator. Some incorrect notation was seen (such as integration signs remaining after integration) but this was not penalised. A small but significant number of learners did not include an arbitrary constant.

Advice for teachers and learners:

Learners who do not process the indices and/or coefficients immediately when integrating (or differentiating) often make subsequent errors with their expression so this approach is not recommended. A recommended approach is to go straight from $2x^{-\frac{3}{2}}$ to $-4x^{-\frac{1}{2}}$ rather than $\frac{2}{-\frac{3}{2}+1}x^{-\frac{3}{2}+1}$.

Question 6

This question on the discriminant was perhaps a little more accessible than many previous questions on this topic and quite a number of fully correct solutions were seen.

The required method was recalled by many and most started by processing the equation to get all terms on one side. A few responses demonstrated sign errors. Most then went on to attempt the discriminant and it was fairly rare to see errors such as applying $b^2 + 4ac$ instead of $b^2 - 4ac$. Some attempts were unnecessarily embedded within the quadratic formula. This appeared challenging as some responses included the "x"s, although many were able to remove them later and

recover. Errors were also caused by the presence of the two variables. A common error was to remove the -2 from $c = 9k - 2$.

Errors in expanding the expression were seen but a correct 3TQ was widely obtained. This question required all stages of working to be shown however a significant number of learners solved the quadratic by calculator. Because the discriminant led to a quadratic with a negative x^2 coefficient, $-44k^2 + 120k + 36$, most learners simplified this to $11k^2 - 30k - 9$, but that often meant that they then chose the inside region and not the outside one.

Advice for teachers and learners:

It is worth reiterating to learners that if inequalities are multiplied or divided by a negative number then the inequality must be reversed.

Question 7

This question on trigonometry in radians with arc length and sector area saw very good scoring on the whole.

In part (a), the arc length formula was widely recalled and applied correctly. The units for the required length were not given in the demand for the question and so there was a mark available for "cm" but many omitted the units.

Performance in parts (b) and (c) was a little more mixed, mainly due to errors working out the angle *AEB*, with many not using the correct $2\pi - \frac{\pi}{2} - 3.5$. Common errors were to use π for 360° and/or $\frac{\pi}{4}$ for the right angle. In some cases, mixed units were seen. Some converted to degrees with mixed outcomes.

Most who made a substantial attempt at the question did sensibly opt to use the cosine rule to find the length of *AB*. The formula was not always recalled correctly.

There were more protracted methods which bore mixed results. Weaker responses assumed that the angle *ABE* was right-angled or that the triangle was isosceles with *AE* = *AB*. Those who had obtained the correct length for *AB* could usually form an appropriate expression for the perimeter although premature rounding prohibited gaining of the final mark.

In part (c), most were able to use the triangle area formula correctly although a few omitted the $\frac{1}{2}$ from $\frac{1}{2}ab\sin C$. There were a few more protracted methods which had mixed outcomes. The sector area formula was generally well-remembered. Premature rounding prevented attainment of the final accuracy mark.

Advice for teachers and learners:

In contextual questions where units are not explicitly mentioned in the demand but have been referred to earlier in the question, the correct units are often expected in the answer.

Many learners appear to find working in radians challenging. Converting to degrees is not required and can increase the chance of error. Learners also should ensure they are using the correct angle unit mode on their calculator when evaluating trigonometric expressions.

Premature rounding can prevent attainment of accuracy marks. Learners are advised to keep the actual values on their calculators and not to round intermediate answers.

Question 8

This question on straight lines intersections and a simple transformation saw extremely good access given that it was a later question. Slightly less success

was seen with part (b) - commonly due to learners not providing a sketch - which was expressly stated in the demand.

Part (a) saw many learners obtaining full marks. There were a few who made errors finding the equations of the lines, but this was rare. Most then proceeded to solve appropriate equations where a few errors occurred. A small but significant number did not give the answers as exact fractions as requested.

Part (b) required a stretch of the given graph by a scale factor of $\frac{3}{2}$ in the *y*-direction. Most were able to appreciate this and only a small number computed incorrect coordinates. The most common recurring error was for learners to only give the coordinates of the transformed points.

Advice for teachers and learners:

Careful reading of the question is always critical. Marks were not able to be obtained here by those who did not fulfil the requirements to "...give your answers as exact fractions" and "Sketch the graph.."

Question 9

This question on the equation of a normal and integration saw a lot of marks awarded. Algebraic or processing errors included finding the tangent instead of the normal in part (a) and also no inclusion of a constant in part (b).

In part (a), most knew that they had to evaluate the expression when $x = 4$ and it was unusual to see this miscalculated. Although the expression was written as f'(x) on the question paper, a small number of learners attempted to differentiate it. Although a straight line equation was produced appropriately by most, it was often for the tangent and not the normal. Those who read the question carefully usually performed the perpendicular gradient rule correctly and went on to score all four marks.

Part (b) had similarities to question 5 in that the expression had to be simplified before integration and most made progress with rewriting the expression. The process for integrating was again generally well-understood but there were occasional sign and coefficient errors. A significant number of learners did not add and find the value of a constant.

Advice for teachers and learners:

This paper commonly features both tangents and normals and it is important that learners read question instructions carefully in this regard.

Not adding an arbitrary constant when integrating appears to be a common error.

Question 10

The final question was on curve sketching followed by some surd work. Stronger responses did extremely well here and even the weaker ones were able to access plenty of the marks in parts (b) and (c).

Part (a) was the curve sketch and the appearance of unknown constants in both the curve equations (whose sketch graphs were asked for) appeared challenging for some learners.

Most were able to recognise that the first graph was quadratic but it was occasionally drawn as a $\cup$ shape instead of a $\cap$ shape. Most identified the curve's intersections with the x-axis correctly. The other graph was a cubic and although most drew a graph with a minimum and a maximum, these were often in the incorrect order. Those who realised they needed a negative cubic usually put its minimum at the origin and often scored all 5 marks. There were a few cases of learners trying to find algebraic expressions in terms of a and b for the intersections.

Part (b) saw most marks being scored by almost all learners who attempted it. The equations had to be set equal to each other followed by some simple manipulation. Very occasionally an error, usually with a sign, was made.

Part (c) again had the warning that learners had to demonstrate how to solve the problem without relying on a calculator. Many correct answers were seen for the solutions of the equation from part (b) but if they were just written down then the first two marks were not available. The next mark required use of one of their x coordinates of the right form to be substituted into one of the curve equations to find another numerical expression of the correct form. Despite the warning, some only reported the value of a y-coordinate but this still gained credit if it was consistent. The final two marks required working - a method needed to be explicitly shown and this often was not there. These marks also required working with the correct root and some thought that this couldn't be $4-2\sqrt{3}$, assuming it to be negative. Learners might find it helpful to bear in mind the diagram in (a) when answering the question. Using the quadratic to find the y values would have been more appropriate than using the cubic, as learners sometimes resorted to their calculator to compute the answer. The final mark required the precise point to be identified and some who found the coordinates for both of the non-zero solutions from the equation in (b) did not indicate which was the point A.

Advice for teachers and learners:

A set of axes was provided in the answer book. Learners are advised that if they make a mistake sketching on the axes, it is perfectly acceptable to cross out the first attempt and re-draw the sketch on their own set of axes. Some tried to make additions or corrections to graphs they had drawn on the answer book axes which often led to an ambiguous diagram.