Examiners' Report
Principal Examiner Feedback

Summer 2022

Pearson Edexcel International GCSE

In Further Pure Mathematics (4PM1)

Paper 02

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<u>Question 1</u>

This question was generally answered well by most candidates and full marks was seen quite often. However, a significant minority still struggled with basic algebraic manipulation which in turn was costing them what should have been easy marks. The common errors for losing the first M marks were substituting $5k$ as their c instead of $5k-3,$ or poor substitution of terms into the discriminant such as $5k^2$ rather than $\left(5k^2\right)$ which led to incorrect manipulation of the algebraic expression. A number of candidates obtained the correct two term quadratic but then divided through by *k*, hence only obtaining one critical value and losing three out of the four available marks, as they were unable to form an 'inside region'. A small number of candidates lost the final A mark for either leaving their answers in terms of two separate inequalities or using greater than or equal to zero.

<u>Question 2</u>

This question was generally answered well with candidates demonstrating a good knowledge of the use of differentiation to find velocity and acceleration. The majority of candidates answered all three parts correctly and full marks was often seen.

(a) Where errors were made, candidates often substituted the value for *t* into the original expression. However, we did see some candidates integrating with respect to *x*.

There were fewer errors in b) and c) with most marks lost through poor attempts at differentiation.

(b) Those candidates who knew that *P* is at rest when $v\left(t\right)=0$ could easily set up a cubic equation to find the correct value for *t*. A few, however, thought that at rest would imply the solving of $x\left(t\right)=0$.

(c) Most candidates knew that to find the acceleration the expression for *v* needed to be differentiated and we saw very few errors here.

In general, even with some errors seen in the process the method marks for the general rule of differentiation were awarded for knowing that the power of at least one term decreased by one.

It was very pleasing to note that candidates tended to give units with their answers [even though these were not required], showing a deep understanding of what was needed of them and how the parts of the question linked together.

Question 3

(a) There were a number of students who failed to understand the question and used the **i** and **j** in their squaring. But those candidates were familiar with the notation for the magnitude of the vectors and were able to write a correct expression in terms of *p*. A significant minority of candidates struggled with squaring the **i** and **j** components with $(2p+1)^2$ becoming $4p^2 + 1$ a common error. Those that were able to deal with the algebra usually went on to solve the resulting quadratic correctly and then select $p = 3$ as the only feasible solution.

(b) It was clear that some candidates were not familiar with the term 'unit vector' and unsurprisingly these students made little progress in this part. Those that did know the method and had a correct answer for part (a) usually went on to achieve the required result and those who had made slips in (a) were usually able to pick up the three method marks in this part despite sometimes having rather complicated expressions for $\overrightarrow{AB}$.

Question 4

This was very much an all-or-nothing question. Students who could see how to split up the given area generally went on to get full marks efficiently and accurately. However, the majority of students could not make a start on this problem-solving question. The most common erroneous strategy was to split the shape down the middle and then treat it as two semi-circles. Few candidates even recognised that triangle AO_1O_2 was equilateral and therefore the angles required were 60° or $\frac{\pi}{3}$.

The rare student who started with the right idea but made mistakes would have benefitted from clearly showing themselves which areas they were calculating at each stage. As usual, successful students often used little pictures of triangles, sectors or segments as appropriate or annotated the given sketch, so they knew what each value represented.

Question 5

(a) On the whole, this question was generally well answered and a good source of marks for candidates. Virtually every candidate knew knew how to find the sum and product of roots correctly, although there were some students who suggested sum of roots was $\frac{b}{a}$ and the product was $-\frac{c}{a}$. Whilst we awarded the B mark for $-\frac{(6+2p)}{2}$ seen, this was sometimes subsequently simplified to $-3+p$, which resulted in loss of accuracy marks in part (b).

(b) This was answered well by the majority of candidates, and many appeared to know the identity $(\alpha-\beta)^2=(\alpha+\beta)^2-4\alpha\beta$ and were able to just write it down. Some students wrote all the algebra to support their answer on this part which was pleasing to see. There were some who seemed to make up the algebra as they went along until they got to the given answer. A few students expanded $(\alpha+\beta)^2$ to rearrange and get an expression for $\alpha^2+\beta^2$ and then used that with $(\alpha-\beta)^2$ to get the answer. There were some sign errors, often from those who had left the sum of roots in the form $-\frac{(6+2p)}{2}$, particularly if they had omitted the brackets. Having the answer given in the question meant that the students had something to aim for but did sometimes mean that incorrect algebra led to a hopeful answer.

(c) Virtually every candidate who attempted this part of the question was successful. There were some who divided by p and lost a solution meaning that they could not score the second mark. Other errors were made by students who lost marks trying to square root their answer to part (b) and setting that equal to 3.

Question 6

(a) The majority of answers to this part were correct and gained both available marks. As this was a show question and the "answer" was given, centres should advise candidates to be careful to state every step they use to get to the result. Just stating the required identity obviously gains no marks!

(b) Nearly all candidates correctly recognised this part of the question as a definite integration. However, many did not use the correct formula. A common error was to use

$\pi\int_0^{\frac{\pi}{4}} y \, dx$ and not $\pi\int_0^{\frac{\pi}{4}} y^2 \, dx$

A significant number of incorrect expansions of $(3+2\sin x)^2$ were seen which was surprising. A small minority of candidates attempted to substitute for $(\sin x)^2$ the identity from part (a) before attempting to integrate. It is very often the case that results from part (a) are required in part (b), yet few candidates realised this. This led to many incorrect integrations although we did credit a correct integration of $9+12\sin x+... \rightarrow 9x-12\cos x+...$ and most candidates were able to gain a method mark for this.
Most candidates stated the correct limits, but many failed to substitute them in correctly. Several ignored the zero limit entirely or incorrectly assumed it contributed zero after substitution. Candidates should be advised to demonstrate correct substitution of the limits before trying to calculate the numerical result. We did not credit the method mark where we did not see the 0 explicitly substituted.
Several candidates failed to have π in their calculation at all. Others, though using π at some point, "lost" it along the way.
Poor layout and incorrect/poor use of the integral symbol were common although we do not penalise poor notation in this specification.

Question 7

(i) (a) This proved to be a challenging question to answer for many students although the majority solved part (a) without problems using the formula for $\tan(A+B)=\dfrac{\tan A+\tan B}{1-\tan A\tan B}$.

A few candidates started with the identities $\tan A=\dfrac{\sin A}{\cos A}$ and then used the addition formulae for $\sin(A+B)$ and $\cos(A+B)$. It was impressive to see some of these candidates bring these efforts to a successful conclusion.

(i) (b) It was surprising to note that even though it appeared obvious that all candidates had to do was to equate the form of $\tan 2A = 1$ they did not think to rearrange into a 3TQ and often left $\frac{2\tan A}{1-\tan^2 A} = 1$ and took it no further therefore failing to score the first method mark. Some misconceptions in the algebraic manipulation were also seen in this part. A significant minority of responses failed to progress once a quadratic had been formed.

(ii) (a) This part also posed problems with many students using the addition formulae for $\sin(x+30^{\circ})$ and $\cos(x-30^2)$ but failing to either equate the resulting expressions with each other or collect the like terms on their way to simplifying everything to $\tan x = 1$. It was often the case that the second M and final A marks were not scored. Those that did equate used a number of different approaches to achieving an equation relating sin *x* and cos *x*, with substituting values for sin 30º and cos 30º being the most successful. There were, however, some really laboured attempts to proceed from the first equation with a number of candidates struggling with the mix of algebra and trig functions. There were also many attempts to concoct the given result.

(ii) (b) This was attempted by many although not all of them understood that the starting statement should be $\tan 2y = 1$. Many of the candidates only obtained the solution 22.5 degrees, not recognising there was a further negative solution or even extra solutions within the given interval therefore losing the final accuracy mark. The most commonly seen method was the CAST method to achieve two correct solutions but a significant proportion of candidates using this method reached either more than two solutions within the given domain OR gave solutions with incorrect signs. This indicated that either they had an incorrect understanding of the CAST method and how it links to the Trigonometrical graph for $\tan x$ OR that they did not have a mental visual recollection of what the tan x graph looks like within the given domain.

Question 8

Parts (b) and (c) of this question were generally answered well by most candidates, and full marks were seen often for these parts, however part (a) was generally poorly answered, with some candidates either leaving it out altogether or struggling to make any progress.

(a) Most candidates found this part very difficult. A number of them found $4x$ correctly using Pythagoras theorem, while others simply assumed this was $3x$ or $5x$ or just made up another value. Success finding the volume was varied, many candidates missed h from their formula or multiplied $2x$ and $8x$ rather than adding them using a correct formula for the area of a trapezium. The surface area was found to be equally difficult to find with candidates finding $40x^2$ and doubling it, forgetting to double $5xh$ or simply not making a credible attempt. If candidates had an allowable form for the surface area and h they generally substituted correctly, although too many recognized their answer would not be correct so changed their substitution, losing another mark in the process. Candidates should be advised that in these show questions the solution should not be part of their working.

(b) This was answered very well indeed, and full marks were seen often. Very few struggled with the differentiation and almost all correctly obtained $x = 2.56$. There were a number of arithmetical errors when solving the resulting cubic; commonly square rooting or cubing instead of cube rooting, and some candidates substituted 0 instead of solving $\frac{\mathrm{d}S}{\mathrm{d}x} = 0$. The second derivative was generally also found correctly, although a number of candidates did not substitute their x value into this instead solving this = 0 or substituting 0 into their second derivative. Moreover, some candidates were inaccurate in their calculations, meaning x rounded to 2.57 to 2 decimal places and costing the accuracy mark here and invariably in part (c) as well. Candidates who correctly obtained the first derivative, were able to obtain the M mark for the second derivative and were able to gain some marks, although a small of number of them did not multiply 1350 by 2.

(c) Most candidates were able to substitute a positive value of x into S and achieve at least the method mark. Rounding also caused an issue because a correct substitution of $x = 2.56$ gave S = 789.48775 which was often rounded to 789.5 without evidence of the more accurate answer and these candidates lost the A mark as they did not obtain awrt 789. A small number of candidates misunderstood the question, they found the second derivative and justified the x value gave a minimum value of S in this part instead in part (b).

Question 9

This was another very challenging question for the candidates.

(a) Those candidates who could write the equations of the two lines could also take the algebra further and through one of the methods to reach the given expression for Y in terms of k and m.

The majority of candidates scored the first three marks for correct straight-line equations which showed recognition of the perpendicular gradients. Many solutions then included [the most commonly seen] elimination of the y's rather than the x's, creating considerable additional work with frequent algebraic errors. Generally, those who eliminated the x's were able to reach the given answer much more successfully, and those very few who eliminated $(x-4)$ obtained the required solution in three lines of working. As is common with this style of 'show that' question, there were numerous candidates who had unrelated working out that in no way led to the correct solution, but they stated that it did.

(b) This was solved successfully by a handful of candidates. The main method seen was setting equal the two sides of the isosceles triangle. If they reached that point chances were that they preferred to substitute the y-coordinate of C with its expression proved in part (a) in which case the algebra becomes very complicated leading to multiple algebraic errors. Even fewer students identified that the midpoint of AB has its Y coordinate equal to the Y coordinate of the point of intersection found in part (a) therefore easily converting to and solving the quadratic equation in m. Very few recognised that the midpoint was of use in answering the question. This was, one of the lowest scoring parts of the entire paper and was often left blank with no attempt at all.

There was a tiny minority who having drawn a sketch realised that angle BAC is 45º and used this fact to solve the question.

Question 10

Most of the candidates did well in their attempt to change to a common base of either 2, 4, 16, 10 or *x* but then faced difficulties when:

- they attempted to eliminate numbers 2 and 4 in the denominators
- they attempted to use the property $\log A + \log B + \log C = \log(ABC)$

  $\log a + \log b + \log c = \log(abc)$
- they used the property $C \log A = \log A^C$

There were also many mistakes on their attempts to use properties of indices such as

$x^{\frac{1}{2}} \times x^{\frac{1}{4}} \times x = x^{\frac{7}{4}}$

In general, the students showed that they knew that the exponential and logarithmic functions are inverse to each other, and they could undo the logarithm to work out the value of *x* as an exponential expression. Correct solutions were found using all bases 2,4,16, 10 and *x* although most candidates chose to work in base 2. A few trial-and-error solutions were seen which could not score marks as the question clearly stated 'Show your working clearly'. However, there was a good number of students who managed to get full marks in this question.

Question 11

This was a challenging question for many. A significant number of candidates left this question completely blank. Those who attempted it, even with a lot of working, often scored just a few of marks and attempts scoring full marks were rarely seen.

(a) Most candidates knew how to use the quotient rule to find the derivative (product rule was only seen a few times), but a large number of candidates made bracketing errors, hence often losing the final accuracy mark. The second term in particular was problematic, with candidates struggling to deal with $(2a-1)x+1$ and thinking of it as $(2a-1)(x+1)$. Only a few candidates got the terms in the numerator the wrong way round, and virtually every candidate remembered to square the denominator.

(b)(i) A significant number of candidates did not attempt this part at all, or if they did, they did not obtain the correct tangent gradient of $-\frac{11}{12}$ or else struggled to set up the correct equation to solve for *a*. Only a few managed to remember that *x* was equal to zero at that point. Of those who did arrive at a linear equation in *a*, few actually arrived at the required result.

(b)(ii) The majority of candidates did not attempt this part, or it got lost in the middle of a long question. Those that did often left their answer without *y* =, resulting in B0.

(c) Again, another poorly answered part of the question with a number of candidates not attempting the sketch at all. Despite algebraic work seen on obtaining the asymptotes and intersections, and because we only scored when we saw asymptotes [and intersections] written on a graph, many attempts were gaining no marks. Sketching was generally poor, with a number of curves turning away from the asymptotes indicating that candidates did not appreciate the nature of asymptotic functions.

(d) This was one of the better answered parts of the question, with candidates generally understanding how to set up the correct equation and full marks were seen regularly. Some mistakes in algebraic manipulation were seen after many started out with the correct equation eliminating *y* from the equation of the curve and the normal but ending up with an incorrect two or three term quadratic. Candidates who reached the correct *x* value, often gave it as improper fraction $\left(\frac{265}{72}\right)$ instead of mixed number $3\frac{49}{72}$ but we allowed that for the final A mark.

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