Examiners' Report
Principal Examiner Feedback

Summer 2024

Pearson Edexcel International GCSE
In Further Pure Mathematics (4PM1) Paper 02

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Introduction

This paper appeared to have presented a challenge for some candidates. 'Show that' questions, as ever, pose a particular challenge with candidates not entirely certain how much detail is considered sufficient; it is certainly true that many candidates err on the side of less where they should be erring on the side of showing too much.

Having said that, there were also a large number of extremely well answered papers with a pleasing number of candidates scoring well into the 80 + %.

Question 1

Part (a)

Almost all candidates knew the factor theorem and could apply it correctly to convincingly prove the result in the question.

A few candidates took a more roundabout route of attempting to factorise the cubic leaving a quadratic factor in terms of a, and this approach was less successful in the main.

Part (b)

Most candidates arrived at the correct quadratic factor through long division or inspection of coefficients.

Relatively few candidates scored the final two marks. Some claimed that since the quadratic does not factorise it has no roots. Others got as far as filling in the quadratic formula but stopped short of explaining why this meant the quadratic had no roots. Those who correctly evaluated the discriminant still had to complete the argument of the cubic itself having only one root, and identifying the root as $x = \frac{2}{3}$. Just a small minority jumped through all the necessary hoops to gain full marks.

Question 2

Most students successfully found the sum of the roots $\alpha + \beta$, and the product of the roots $\alpha\beta$, earning the first two B marks without issue. When attempting to find the sum of the new roots, $\frac{\alpha}{2\beta} + \frac{\beta}{2\alpha}$ they recognized the need for $\alpha^2 + \beta^2$. However, there were variations in what $\alpha^2 + \beta^2$ should be, and many were unsuccessful in correctly expanding $\alpha^2 + \beta^2$ resulting in the loss of the third B1 mark. .A very common error was $\frac{2(\alpha^2 + \beta^2)}{4\alpha\beta} \Rightarrow \frac{2\left(\frac{5}{3}\right)^2 - 2\left(\frac{1}{3}\right)}{4\alpha\beta}$ which not only led to the loss of the third B mark, but also to the loss of the first M and A marks as well.

Most students easily found the product of the new equation, thus earning the fourth B1 mark. The majority were able to then manipulate the algebra effectively and substitute **their** values correctly to find the sum of the roots for the new equation. Consequently, most candidates scored the final M1 mark.

This should not detract from the fact that many students found this a very accessible question and it was a good source of marks for many candidates.

Question 3

Part (a)

Most candidates simply did not have a clue how to find the angle. To secure the 3 marks on offer it was necessary to use trigonometry. Correct answers found using the fact that in the triangle *AOC* was an equilateral triangle without any justification scored no marks. That in this special particular case, the triangle is equilateral is a coincidence, and without correct justification we did not allow this assumption.

Part (b)

The most common scoring pattern here was B1M0M0A0 because all most candidates were able to score a mark, [for those who actually attempted the question at all], for writing down the correct formula for the area of a circle. Most of those who got as far as attempting the area of the sector frequently forgot to square $(3r)$ writing the subsequent step as $3r^2$.

This was a disappointing question for many.

Question 4

Candidates found this question very difficult as well and a very large number could not identify how to manipulate the algebraic expression. Considering it is a simple cubic, this was somewhat surprising. Correct answers were often seen without any relevant working, clearly using technology to find the solutions and it is vital candidates do not become overly reliant on this and can still carry out formal methods.

Correct solutions quoted without supporting algebraic working and the evidence of a correct straight line were awarded M0A0M0A0.

Those candidates who understood how to attempt the question often reached the correct equation of the line and plotted it correctly, and then used the line to find the required points. However, it is vital candidates read the question carefully for the required degree of accuracy required as too often this was overlooked. This is one question where we insist on the answers being rounded to the accuracy we specify. In any case, giving answers to 2 or 3 decimal places on a hand drawn graph is clearly absurd.

It was also common for candidates to give 0.2 as a response rather than – 0.2.

There are several questions like this set in the past: it is worthwhile to revisit past questions on Examwizard to practice these skills.

Question 5

Generally, the majority of candidates attempted to find the first and second derivatives of y using the Product rule, thereby producing a lengthy algebraic expression involving algebraic and exponential terms, which they endeavoured to reduce to $2e^{2x}$, the RHS of the equality.

The product rule was generally well understood, though occasionally a minus sign appeared between the terms and occasionally there were mistakes in differentiating e^{2x} or $x^2 - 5x$.
The majority of errors were seen in the lengthy expansion of the RHS by substituting for $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y$.

Those candidates who simplified the first derivative to either $e^{2x}\left(2x^2 - 8x - 5\right)$ or $2e^{2x}x^2 - 8e^{2x}x - 5e^{2x}$ and then the second derivative to $e^{2x}\left(4x^2 - 12x - 18\right)$ or $4e^{2x}x^2 - 12e^{2x}x - 18e^{2x}$ were generally the most successful.

A number of candidates were more astute and replaced expressions by y or $\frac{dy}{dx}$ whenever they were recognised.
This was a successful question for many candidates and a good source of marks.

Question 6

This question overall proved very challenging for the candidates and highlighted poor algebraic manipulation in a number of cases from the squaring of $\left(\frac{1}{4y}\right)$, as well as manipulation of the result of that into a form suitable for integration. Also, a good proportion of the candidates rotated around the x-axis which limited the marks available [only the M marks were available] and this also was carried out very poorly.

<u>Part (a)</u>

Most candidates who attempted this, achieved full marks here. Errors seen included square rooting, rather than cube rooting, or candidates whose notation was poor and subsequently misread their own writing treating the equation as $2x^2 = \frac{1}{4x}$

Part (b)

Many candidates recognised they needed to rotate around the *y*-axis and found $x^2 = \frac{y}{2}$ and $x^2 = \frac{1}{16y^2}$. Integration of $\frac{1}{16y^2}$ was often poor with many candidates rewriting as $16y^{-2}$. Also, a good number subtracted the two expressions the wrong way round but we condoned this if a candidate corrected their answer at the end.

Many candidates attempted to find a volume based on rotating around the *x*-axis. We awarded up to 3 SC [special case] marks her, but those who attempted this method scored one or two marks at most usually for an acceptable integration of one of their terms.

Having said this, there were a pleasing number of fully correct solutions seen.

Question 7

This question was generally answered very well and was a good source of marks for many.

Part (a)

Apart from some occasional sign errors, this part of the question was answered well with many candidates scoring M1A1A1 without any trouble at all.

Part (b)

Some candidates did not understand what was involved here but the responses overwhelmingly indicated that many are well versed in this type of question and also able to pick up both marks on offer.

Part (c)

Whilst the majority of responses were fully correct, a significant minority made sign errors here, the most common being extracting an incorrect value for the coefficient of x^2. For some inexplicable reason, having found a fully correct expansion in (b) many candidates used a value of 3 instead of – 3, thus losing both marks on offer here.

Question 8

This question was on the whole answered quite badly, with poor accuracy in the differentiation of S and $\frac{\mathrm{d}S}{\mathrm{d}x}$. However, candidates who persevered and used their answers were able to pick up a mark in part (c).

Part (a)
Most candidates found DE or an equivalent length and attempted to form an expression for S. There were some good examples of manipulation but also some that lacked correct method and simply wrote the given result in an attempt to gain marks.

Part (b)
Most candidates attempted to differentiate the given expression acceptably for S although it was disappointing to see how few were differentiated completely correctly. Some overcomplicated it by writing the expression over a common denominator and using the quotient rule, some reverted to working in decimal form and as a result lost accuracy. A significant minority were able to go on to achieve the required value for x.

Performing the mathematics required to conclude that the value found was a minimum was very poorly executed. This often-scored B0 due to the form of the 2nd derivative being incorrect as many differentiated x into 0, and as such this mark was unavailable to them. Those who achieved this mark, often gained full marks on this question.

Part (c)
Most candidates if they had found a value in (b) for x used this value to score the M mark. Candidates who successfully found x = 3.26 in (b) often gained full marks in (c)

Question 9

Part (a)
Most candidates appreciated that angle AFC = 180 – 60 – 45 = 75, or 75 = 45 + 30. Thereafter, a number were unsure how to proceed and there were a number of non-attempts. Some candidates were tempted to use the Sine rule at this stage without benefit.

Successful candidates used a variety of combinations of angles for sin75 degrees; sin(120-45), sin (60 + 15) and sin (45 + 30) with sin (A + B) to obtain the required answer $\frac{\sqrt{6}+\sqrt{2}}{4}$.

We did not allow however, for example, sin (90 – 15), because no manipulation with surds was required for this mark and the required expression was generated directly from the calculator.

Part (b)
The majority of candidates appreciated that the Sine rule was required here, and most were able to apply that successfully with the given result from part (a). Less successful were the attempts to rearrange to obtain $BF = \frac{48\sqrt{3}}{\sqrt{6}+\sqrt{2}}$ or its equivalent. Thereafter, more able candidates appreciated that in order to rationalise the denominator, multiplying by the conjugate of $\sqrt{6}+\sqrt{2}$ was required.

Many candidates skipped this part of the proof and simply declared $BF = 12\left(3\sqrt{2} - \sqrt{6}\right)$ as required. Algebraic facilitation with roots seemed a problem for some candidates.

Part (c)

This part was far too frequently left completely unanswered.

It appeared that a wedge was an unfamiliar solid to a number of candidates and the geometry of it was beyond them. Candidates appreciated that the vertical from *F* to *AB* was required and unfortunately for some they assumed that the foot of the perpendicular from *F* to *AB* was the mid-point of *AB*.

Thereafter the perpendicular from *F* was found using the value for *BF* from (b).

For example, $\frac{FX}{BF} = \sin 45 \Rightarrow FX = 36 - 12\sqrt{3}$

Then in the other dimension, $\frac{FX}{EF} = \sin 65 \Rightarrow EF = \frac{36 - 12\sqrt{3}}{\tan 65} \Rightarrow EF = 7.1$

Many candidates struggled with dimensional awareness in this question.

Part (d)

This was the least successful part of the question, as many candidates could not identify the angle required, angle *FCX*. A number of candidates mistakenly identified the required angle as angle *FCA*.

Having identified the required angle, candidates could proceed to find *FC* using Pythagoras Theorem with *BF* and *FE*; thereafter $FCX = \sin^{-1}\left(\frac{FX}{FC}\right) \Rightarrow 42.2^{\circ}$

Question 10

Part (a)

One mark out of three was a common score here. Most candidates realised they had to deal with vectors of opposite sides of the parallelogram, but several got confused by the difference between, for example, *CD* and *DC*. Relatively few realised they had to consider both pairs of opposite sides, and fewer still rounded off their argument with a suitable conclusion.

A small number believed that showing pairs of vectors had equal magnitudes was sufficient.

Part (b)

Many candidates drew an adequate diagram to facilitate progress.

A minority of candidates were well-versed in the relevant technique of finding two routes involving parameters for the same vector, and those who did this usually went on to set up and solve the relevant simultaneous equations correctly.

Rather more candidates got bogged down in trying to find any worthwhile and correct vector involving the point *D*, and sign errors in vectors were in abundance.
Many candidates were simply unaware as to how to make progress with this question.

Question 11

Part (a)(i)

Whilst many candidates correctly used the correct identities to prove this statement, too often they missed vital steps that should be required in 'show that' or 'proof' questions. Many candidates progressed from $\cos 2A = \cos^2 A - \sin^2 A$ to without showing the intermediary step. Sign errors were also very common here.

Part (a)(ii)

Well-answered almost without exception.

Part (b)

This was generally poorly answered. Many candidates attempted the correct addition formula as their first step, while a number did correctly use a correct addition formula. From here candidates either progressed correctly with the proof or made no progress at all.

Part (c)

Candidates found this difficult with many making no progress at all. Others correctly substituted to find the correct form and then used a substitution of, for example, but then only found *A* rather than θ.

Part (d)

Again many candidates made no attempt at a substitution and attempted to integrate directly. We generously awarded one M mark for integrating the $-\sin 2\theta$ term.

As always, centres should advise and encourage to show explicit substitution of their limits to ensure maximum access to marks.

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