Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

November 2021

Pearson Edexcel GCE
In Further Mathematics
Paper 02 Core Pure Mathematics 2

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Question 1

A gentle start to the paper, but it still had its pitfalls.

Part (a) Candidates generally had no problem finding the modulus, most able to just write it down. However, the argument did produce errors, a large number thought that the argument of $z_2 + \frac{\pi}{12}$ when it was $-\frac{\pi}{12}$ leading to an incorrect answer of $\frac{5\pi}{12}$. Candidates are reminded to look out for the minus sign in $z_2 = \sqrt{2}\left(\cos\left(\frac{\pi}{12}\right) - \mathrm{i}\sin\left(\frac{\pi}{12}\right)\right)$

Part (b) Candidates who achieved the incorrect answer to part (a) s=then struggled to answer part (i) with many thinking that $n = 0$ and, therefore invalid as n was a positive value. If the candidate had the correct answer to part (a) a common error was stating that $n = 4$, which would give and argument of π.

Question 2

The majority of candidates thought that an invariant line must consist of a line of invariant points and so were not able to produce a comprehensive solution.

Only a handful of candidates were able to produce a fully comprehensive solution by not confusing their x's when mapping (x, mx) onto (x, mx) rather than (x, mx) onto (X, mX).

Question 3

Part (a) Nearly all candidates knew what was expected and found the first and second differentials of f(x) correctly. However, a few problems occurred in progressing correctly to the third differential, particularly losing an x along the way.

Generally, candidates were able to use their results correctly in the Maclaurin's series to produce a series in x, in its simplest form.

Part (b) Most candidates substituted ½ for x in their expansion but a quite a few forgot to equate to substitute ½ into $\arcsin x$ to achieve $\frac{\pi}{6} = \ldots$ and thus failed to find an estimate for π.

Question 4

Part (a) A standard question which, as expected, was well done by most candidates. As one would expect there were a few errors made in expansions along the way.
The majority of candidates used $2r - 1$ as their odd number and were able to expand and sum from 1 to n. Unfortunately, those candidates who decided to work with $2r + 1$ also attempted to sum from 1 to n rather than 0 to $n - 1$ which meant that that were unable to prove the result but still managed to gain 3 out of 5 marks.
(b) This was a discriminator with only the strongest candidates being able to find a successful approach. Quite a few candidates just equated the result of (a) to 99800 which clearly cannot lead anywhere. Candidates also subtracted to create either 9 or 11 consecutive odd numbers instead of 10. The few who work with one of the alternative series subtractions that actually involved 10 consecutive numbers made a good start but many made careless errors in collecting terms in producing their cubic equation. This left very few who were able to successfully complete the correct solution of 11.

Question 5

Part (a) A majority were able to differentiate to find $\frac{\mathrm{d}y}{\mathrm{d}x}$ in the correct form, although a very significant number omitted the ½ in the numerator.
Candidates are reminded that if they apply a substitution, here $u = \frac{1}{2}x$, find $\frac{\mathrm{d}u}{\mathrm{d}x}$ and complete the full substitution. Having achieved this there were problems for many in attempting a comprehensive argument for C having no stationary points although they clearly knew why.
Part (b) Most candidates used their result for the differential in part (a) to find the gradient of the tangent when $x = 1$ and used this to find the gradient and equation of the normal at the point $\left(1, \frac{\pi}{3}\right)$. A few actually went completely wrong at this point, finding the equation of the tangent.
Candidates then went on to find where their normal crossed the coordinate axes and applied the area of a triangle. This did cause a problem for the majority who did not realise that one of their y coordinate was negative and that they should have used area of the triangle $OAB = \frac{1}{2} \times x_A \times -y_B$.

Question 6

Part (a) The majority started well using $x = r\cos\theta$ to find $\frac{dx}{d\theta}$ correctly.

Setting $\frac{dx}{d\theta} = 0$ and factorising, but many missed the significance that $\sin\theta = 0$ is a solution which leads to two solutions. The other factor leads to $\cos\theta = -\frac{p}{4}$ and candidates need to use the fact that as $\cos\theta < -1$ leading to $-\frac{p}{4} > -1 \Rightarrow p < 4$. Only a very small number of candidates were able to complete the proof successfully.

Part (b) The vast majority, using the information that there are four points on *C* were the tangent is perpendicular to the initial line, knew what this curve looked like, although a small minority either drew a circle or made the curve pass through the origin.

Part (c) Most candidates knew what was expected here using either $2\times\frac{1}{2}\int_0^{\pi} r^2 \, d\theta$ or $\frac{1}{2}\int_0^{2\pi} r^2 \, d\theta$. Most candidates knew that they needed to use $\cos 2\theta = 2\cos^2\theta - 1$ to be able to integrate. There were occasional careless slip, but candidates were able to use limits correctly to proceeded to find the area of cross section. Candidates then needed to multiply this by 90 and divide by 50 litres which is equivalent to 50000 cm^3, to obtain the final answer. The correct solution of 25 mins was not that common due mainly to errors during these final arithmetic steps, often the π became lost along the way.

(d) Too many candidates thought that a possible limitation related to the flow of water, which is not part of the model. Candidates are reminded to look back at the question and identify were the model set up. So in this question

'The pond has a uniform horizontal cross section that is **modelled** by the curve with equation $r = 20(3 + 2\cos\theta)$'

Question 7

Part (a) Was very well done by the majority. Using the exponential definition of sinh *x* or the natural log representation of arsinh *x*. A few who took the latter root went wrong by squaring $\alpha + \sqrt{\alpha^2 + 1} = \sqrt{3}$ instead of rearranging to $\sqrt{\alpha^2 + 1} = \sqrt{3} - \alpha$ then squaring.

Part (b) This was generally well done, with candidates correctly using the volume of revolution formula. Expressing $\sinh^2 y$ in terms of exponential or using the double angle formula for cosh 2*y* were equally popular, to arrange it an integrable form. There were many fully correct attempts but some with careless slips along the way followed through to an incorrect conclusion. There were also some candidates who used $\sqrt{3}$ as the upper limit instead of $\ln\sqrt{3}$

Question 8

Part (i) Most candidates were able to correctly find the modulus and argument of 6 + 6i and a majority also realised that the angle at the center of a regular pentagon is $\frac{2\pi}{5}$. They then either added or subtracted multiples of $\frac{2\pi}{5}$ to their original argument to obtain the required arguments. Having done this successfully a few candidates failed to give their final answer in the correct format.

(ii) Part (a) Quite well done on the whole. Candidates recognised that a circle with centre on the y axis and passes through the origin but some candidates failed to indicate that the radius of the circle was 2. Candidates are reminded to indicate key coordinates on graphs.

(ii) Part (b) This was well done by the majority of candidates by expressing the circle as a polar equation $r = 4\sin\theta$ and finding the required area between $\theta = \frac{\pi}{4}$ and $\theta = \frac{\pi}{3}$.

Question 9

Part (a) Although most candidates did obtain $\frac{1}{1-z}$ a minority did not seem to remember geometric progressions.

Part (b)

(i) Candidates who made good progress with this art substituted $z=\frac{1}{2}(\cos\theta+\mathrm{i}\sin\theta)$ or $z=\frac{1}{2}\mathrm{e}^{\mathrm{i}\theta}$ into the answer to part (a) and then attempted to rationalise the denominator. Candidates then simplified and selected the imaginary part. However, the question required candidates to prove that for the series $\frac{1}{2}\sin\theta+\frac{1}{4}\sin 2\theta+\frac{1}{8}\sin 3\theta+...=\frac{2\sin\theta}{5-4\cos\theta}$ and to complete the proof candidates needed show that when you substitute $z=\frac{1}{2}(\cos\theta+\mathrm{i}\sin\theta)$ into the series that that the imaginary part was $\frac{1}{2}\sin\theta+\frac{1}{4}\sin 2\theta+\frac{1}{8}\sin 3\theta+....$ They then needed to equate the imaginary parts to proof the required statement. A few candidates did the consider the first term of the series and so they could not achieve full marks since the first term is part of the series.

(ii) Probably the least successful part of any question on the paper. Most candidates just said that there would be real parts without attempting to show that the real part cannot be zero. Candidates needed to set the real part of the series form part (i) equal to 0 and show that this was not possible.

Overall candidates were able to have a good attempt at all the questions with the exception of question 2.

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