Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

Summer 2019

Pearson Edexcel International A Level
In Further Pure Mathematics F2
(WFM02/01)

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Introduction

This paper proved to be a good test of student knowledge and understanding. It discriminated well between the different ability levels. There were many accessible marks available to candidates who were confident with topics such as inequalities, differential equations, Taylor series, complex numbers, series summations and polar coordinates.

Reports on Individual Questions

Question 1

This question proved to be accessible to most candidates and it was a very good source of marks for the vast majority. It was rare to see anything other than a clear attempt at solving at least one of the required quadratics in order to arrive at, at least one of the critical values. Candidates who attempted to find the roots of the LHS ($\pm\sqrt{6}$) usually ended up with an incorrect solution. While some candidates resorted to symmetry to find the critical values most knew how to deal with the modulus sign successfully in order to arrive at the correct critical values. Tables of signs and sketches were equally common when trying to decide on the correct final solution, but it was also a common error among candidates to try and incorporate all the critical values in their final answer without resorting to a simple sketch to ascertain which ones were consistent with their diagram. Only a very small number chose to square both sides to produce a quartic and only the most competent candidates achieved a fully correct solution from this method. Some candidates made careless mistakes with, for example, $2 < x$ instead of $2 > x$. The use of non-strict inequalities in the final answer was rare. Set notation was not commonly used.

Question 2

This question on a transformation using complex numbers was also a good source of marks for many candidates. Way 1 on the mark scheme proved far more popular than Way 2. A very small number made errors in making z the subject of the formula. Weaker candidates were often unsure about how to progress but most others replaced w with u + iv and used a correct method to multiply numerator and denominator by a suitable conjugate. Some were unable to then identify that since the transformation was of the imaginary axis, the real part of the resulting expression needed to be set equal to zero. For those who knew how to make progress, common errors were mainly with the resulting simplification or sign errors when equating the real part to zero, or in equating the real and imaginary parts. Way 2 was not an efficient method on this occasion and the small number who chose this method were often unable to eliminate y from their equations.
Those who obtained a correct circle equation invariably proceeded to deduce the correct coordinates of its centre and its radius although a few candidates could not complete the square correctly and it was more common to see a correctly completed square from an incorrectly simplified equation.

Question 3

Q03 involved using the method of differences. It was very rare to see any errors in obtaining the correct partial fractions in part (a). The scoring in part (b) was slightly more mixed. The general method was widely known (and for the most part well executed) but some candidates failed to notice that the summation started at r = 2, usually leading to the indeterminate form of $\frac{1}{0}$ (computed as 0 or 1) appearing in their non-cancelling terms. Some of these candidates were able to recover by subtracting the r = 1 terms later. Those who had obtained terms of the correct form usually scored the second method mark with an appropriate attempt to combine these terms. The full five marks were commonly awarded. Part (c) had the command word "Hence" and required the given result from part (b) to be used. Unfortunately, some candidates chose to repeat the differences work from earlier and some went on to achieve the correct result but did not receive any credit as they hadn't used the 'hence' requested in the question. The correct expression for S_{3n} was widely seen although some then subtracted S_n rather than S_{n-1}. A few found the resulting algebra rather intimidating – usually making the mistake of needlessly multiplying out all the brackets.

Question 4

This first order differential equation question was a little more discriminating. Most knew to divide through by cos x although this was not always carried out successfully, in particular with the terms on the right hand side leading to a common error of failing to divide the final term by $cosx$ and arriving at $\int secx$ instead of $\int sec^2x$ for the final term. Correctly obtaining sec x as the integrating factor was common. A small number of candidates remain confused about how to correctly apply the integrating factor – the most common error being the failure to multiply Q(x) by I. Those who had obtained $\int (2\cos x \sin x - 3\sec^2 x)\,dx$ were usually able to integrate successfully. Most candidates recognised $\int 2sinxcosx$ as $\int sin2x$ and obtained $-\frac{1}{2}cos2x$ and it was rare to see this evaluated as $-cos^2x$ or sin^2x. Only a small number failed to divide through by sec x (or multiply by cos x) to obtain y as a function of x at the end.

In part (b), the method mark was often scored, but there were a few slips obtaining the constant. A few obtained the correct constant but then failed to place it correctly into the particular solution. A common error was to assert that $3\sqrt{3} + 3\frac{\sqrt{3}}{2} = 3\frac{\sqrt{3}}{2}$. The simplification of $\frac{-3tanx}{secx} = -3sinx$ caused problems for some when attempting to evaluate their constant of integration.

Question 5

Q05 involved finding the fourth roots of a complex number. In part (a) the correct value for r was almost always achieved but many had an incorrect strategy in obtaining the argument. Some gave a correct equivalent value for θ but it was not in the specified range. A very small number went straight to an r (cosθ – i sinθ) form. Candidates who obtained the incorrect argument in part (a) would be advised to sketch a diagram with the point correctly positioned so that they can interpret the argument correctly

Part (b) saw good scoring on the whole. A few candidates did not introduce $\pm 2k\pi$ at any stage and could only obtain one root. Others divided their angle by four first and then introduced the $\pm 2k\pi$ while other candidates got into a muddle when attempting $\pm\frac{k\pi}{2}$ to their arguments. Those proceeding correctly were generally able to obtain all four roots in trigonometric form but occasional slips were made converting into a + ib form, for example writing things like
$-1 + \sqrt{3}$ and $-i - \sqrt{3}$ instead of $-i + \sqrt{3}$.

Question 6

This question on a Taylor series expansion produced a surprisingly mixed response. The general method was well known but many succumbed to errors with the required differentiations, with some failing to deploy the chain and product rules correctly. The second derivative proved more problematic with a significant minority of candidates incorrectly producing an $\alpha x(1 + x^2)^{-5/2}$ term. Those who obtained the correct derivatives were usually able to then produce correct numerical expressions for the values at $x = 1$. A very small number of errors were seen in applying a correct Taylor series. Candidates who quoted the correct expansion formula usually obtained the M mark when substituting in their values, but it was evident that an over reliance on calculators left many unable to correctly simplify the resulting expression for the third coefficient which left them with an inexact form. The final mark was occasionally withheld for an unsimplified answer or in cases where candidates had reverted to decimals. It was interesting to see the common error amongst candidates of interpreting $-(2)^{-\frac{3}{2}}$ as $-\frac{1}{\sqrt[3]{2}}$ instead of $\frac{-1}{(\sqrt{2})^3}$.

Question 7

This question on a second order differential equation saw an encouraging number of completely correct solutions. Scoring was good in part (a). Most knew to obtain $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ from $y = vx$ and then substitute to obtain the given answer. Those who worked with other derivatives generally did not make much progress although a small number who obtained $\frac{dv}{dx}$ and $\frac{d^2v}{dx^2}$ were able to use these to find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$. A very small number of candidates substituted into (II) to derive (I).

A few errors were seen in forming the auxiliary equation in part (b) with $m^2 - m = 0$ rather than $m^2 - 1 = 0$ occasionally and the correct equation was sometimes solved incorrectly to give
$m = \pm$ i rather than ± 1. The correct form of complementary function was usually obtained although a few gave the form for equal roots. The mark for a correct particular integral of –2 was widely scored although a small number needlessly started with forms such as $\lambda + \mu x$ or $\lambda + \mu x + \nu x^2$. Most added their CF and PI but some were not working with v here and gave this expression as their final answer. However, the correct solution in the form $y = f(x)$ was widely seen.
In part (c), the method was again clear to most candidates although the product rule was not always used to obtain $\frac{dy}{dx}$. Most obtained two equations in A and B but the algebra required to solve them simultaneously often led to error. Candidates persisting with their "v =" form were penalised further in this part.

Question 8

The final question on polar coordinates was a good source of marks in part (a) but proved more discriminating in (b).

Part (a) required finding the length of OP where point P was the point of contact of a tangent parallel to the initial line. Most realised they needed to solve $\frac{d}{d\theta}(r \sin\theta) = 0$ although a small number thought solving $\frac{d}{d\theta}(r \cos\theta) = 0$ was required. Most obtained and differentiated $r \sin\theta$ correctly but it proved more difficult to obtain the correct three term quadratic in $\sin\theta$. Those who obtained the correct three term quadratic generally proceeded to find the correct value of r, usually by finding θ first, although a few expressed $\cos 2\theta$ in terms of $\sin\theta$.

In part (b), most used the correct area formula and squared correctly but the resulting term of $2\sin\theta\cos 2\theta$ proved challenging to integrate. Most used $\cos 2\theta = 2\cos^2\theta - 1$ and then integrated 4 $\sin\theta\cos^2\theta$ although a small number used the sum and product formula to obtain $\sin 3\theta - \sin\theta$. The very small number attempting integration by parts, which needed two applications and rearrangement to make $2\sin\theta\cos 2\theta$ the subject, were rarely successful. Some candidates who couldn't integrate this term resorted to evaluating it on their calculator and received no further credit. Those who had integrated successfully, rarely used incorrect limits and the correct exact area was often confidently achieved.

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