Examiners' Report

Summer 2014

Pearson Edexcel International Advanced Level
in Further Pure Mathematics F1
(WFM01/01)

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General Introduction

This paper proved a good test of students' knowledge and students' understanding of F1 material. There were plenty of accessible marks available for all students

Presentation was a concern in some areas for this paper, in particular, the number "2" and the letter "x" were often written badly by many students. It is important that students write numbers, letters and symbols clearly so that marks are not lost unnecessarily.

Report on Individual Questions

Question 1

This question proved accessible for the vast majority of students, with a high proportion scoring full marks. Most, successfully expanded the difference of two squares to give the correct expression of $r^2 - 1$ and went on to apply the $\sum r^2$ formula with $n = 200$. The most common error seen was to write $\sum(-1)$ from 1 to 200 as -1, leading to an answer of 2686699. A small number of students were unable to obtain $r^2 - 1$, achieving instead $r^2 + 1, r^2 \pm r - 1$ or $r^2 \pm 2r - 1$. Some students quoted the formula correctly but then went on to substitute incorrectly. A small proportion of students chose to combine the $\sum r^2$ expansion and the $\sum -1$ to reach an expression in n before substituting $n = 200$. (i.e. $\frac{1}{6}n(n+1)(2n+1) - n$, leading to $\frac{1}{6}n\left(2n^2 + 3n - 5\right)$, or equivalent) Although this was often done correctly, it was not uncommon to see manipulation errors leading to a loss of marks.

Question 2

In Q02(a) very few errors were seen. The only mistake evident was a negation of the real part instead of the imaginary part.

In Q02(b) most successful students used either the sum & product of roots or expanded $\left(z-(-2+3i)\right)\left(z-(-2-3i)\right)$. There was less success for those who attempted to substitute one of the roots for z. Many did not know what to do next, and quite a few solved to obtain complex values for p and/or q. Several students dealt incorrectly with $+3\text{i} \times -3\text{i}$ (evaluated to give + or -3). Others found the sum of roots to be -4 and then stated that $p = -4$.

Question 3

In Q03(a) the inverse matrix was obtained correctly by the majority of students. Most were able to correctly work out the determinant of the matrix, swap the elements of the leading diagonal and change the signs of the other elements of the minor diagonal. Many students did then multiply through by $\frac{1}{\text{determinant}}$, which was not necessary in this part of the question, but often helped them with part Q03(b).

In Q03(b) most students were then able to set up the matrix equation correctly to gain the first M mark here. Comparing elements from the left hand side and right hand side was usually completed correctly but there were often errors in solving the resulting equations. This was usually an error in the manipulation of a linear equation. However, another fairly frequent issue was in solving the quadratic formed from the lower left elements, gaining two solutions of $a = 0$ and $a = 7$. The students did not check that there was only one possible value of a from using the other elements. Less able students failed to state the 2x2 identity matrix. As a result, they could not form an equation and solve for the value of a. An occasional error in this part of the question was multiplying instead of adding the matrices.

Question 4

This question proved accessible for the vast majority of students, with a high proportion scoring full marks. Almost all students evaluated f(4) and f(5) correctly, with most indicating that one value was negative and the other positive. Although most made reference to a sign change, not all made an explicit conclusion that this implied a root in the interval, and the loss of the A mark was the most common error in this part of the question.

Q04(b) was generally well attempted, with few errors seen. The vast majority of students found a correct derivative and applied Newton-Raphson successfully, usually showing this explicitly. Where marks were lost on this part, it was usually due to incorrect rounding to 4.42 or 4.43. Although the majority of students also gained full marks on Q04(c), more errors were seen here than in Q04(b). Most students formed a correct equation in α and went on to solve it. The most commonly seen error was -1 in the denominator, i.e. $\frac{5-\alpha}{1.472}=\frac{\alpha-4}{-1}$, leading to the loss of all marks.

A small proportion of students, having formed a correct equation in α, made subsequent manipulation errors, so losing the accuracy mark. Some students lost marks for failing to give the final answer to the required degree of accuracy. A small number of attempts using interval bisection were seen in Q04(c), as was repeated use of Newton-Raphson in Q04(b).

Question 5

There were very few errors in Q05(a). Any marks lost were due to lack of required labelling. Many Argand diagrams were not presented well with little regard for scale, but labelling enabled the students to earn the marks. In Q05(b) a variety of approaches were used which almost invariably gained the method mark. A small percentage of students failed to conclude that there was a right angle, so lost the accuracy mark, despite a probable understanding of the verification. The most popular approach to this proof was to use "product of gradients is -1", and generally students produced a complete, correct proof using this method. Students who found angles were less clear in their arguments. Arguments involving arctan were less successful, as notation was sometimes ambiguous. Use of Pythagoras' theorem in reverse on triangle OPQ was a rare approach, whereas the scalar product was used by a fair proportion and normally it was very successful. A few students thought that showing $OP = OQ = 5$ was sufficient to show that the angle was 90 degrees.

In Q05(c) almost all students found the sum of the two complex numbers, but a few failed to plot the point on their diagram.

In Q05(d) a large number only scored the first mark ; the question required proof that $OPQR$ was a square. There were many who thought that having two right angles (or even four) was enough to make a square and made no mention of side lengths. Others thought that having two equal sides and one (enclosed) right angle was adequate. Other students mentioned parallel sides without any reference to their lengths or stated that all sides were equal to 5 but failed to mention a right angle in this part.

Question 6

Well prepared students scored full marks on this question. There were occasional algebraic slips. However, the most common mistakes was the inability to recall that the sum and product of roots in a quadratic equation $ax^2 + bx + c = 0$ were $-\frac{b}{a}$ and $\frac{c}{a}$ respectively, and the inability to recall that $\left(\alpha^3 + \beta^3\right) = \left(\alpha + \beta\right)^3 - 3\ \alpha\beta(\alpha + \beta)$.

A number of students thought that $\alpha^3 + \beta^3$ was $\left(\alpha + \beta\right)^3$ and so lost two marks. A number of students worked with individual roots involving surds and were presumably unaware of the sum and product properties. In Q06(b) most students were able to use their sums and products to form relevant quadratic equations. Those who did well in Q06(a) almost always went on to score full marks in part Q06(b). The most common error was a failure to perform basic algebraic manipulation on the sum of the roots. A number of students found the roots of the original equation and proceeded to answer the whole question using them. This often required lengthy manipulations and calculations where mistakes were common.

Only a few students forgot to write the equation in the required form, and even fewer made errors in clearing the fractions.

Question 7

Most students gained the 3 marks in Q07(a) of the question. The most common error was failing to state the centre of rotation, the origin. Occasionally students thought that a scaling was involved as well as a rotation, probably because of the $\sqrt{2}$.

An incorrect matrix was fairly common in Q07(b), with the non-zero entries incorrectly placed, or some variant of the matrix in the question. Q07(c) the majority of students used their answer from Q07(b) correctly to multiply two matrices in the correct order, but a significant number multiplied them in the wrong order, gaining no marks. Some of the more able students were able to write down the answer based on an understanding of the geometry.

In Q07(d) the most common error was the failure to understand what mapping on to itself actually meant. As a result students found it hard to solve for k since that required an equation. Those who understood that the mapping mapped the point onto itself generally used only one equation to find k thus failing to verify that the result for k satisfied the other equation or not solving it to obtain the same value. In the main, the attempts at solving the equation involving surds were generally very good, and the correct answer was common from one of their equations.

Question 8

Q08(a) was well done, apart from the less able students who failed to produce an equation in one variable only. Equations in t, x or y all appeared regularly and produced mostly correct coordinates for A. Virtually every student eventually arrived at the coordinates.

Q08(b) showed that the majority of students were confident with this variation on finding a normal. Explicit or implicit differentiation were the popular approaches with only a few careless errors seen. There were very few students who did not find the negative reciprocal of their tangent gradient and a majority achieved a fully correct linear equation. A few students did not read the question with enough care and attempted to find a normal to the parabola. Relatively few found a tangent instead of a normal.

Q08(c) was also well done on the whole. Some errors were due to a failure to obtain the correct equation in Q08(b). Equations in t were slightly more popular than those in x or y, and those finding values for t and subsequently the coordinate pairs were nearly always successful. Attempting to solve with the hyperbola rather than the parabola and algebraic errors in solving quadratics were the most common errors.

Question 9

In many respects this proved to be the most challenging question on the paper, with Q09(a) generally more successfully attempted than Q09(b).

In Q09(a) most students applied the first steps of the method of induction, evaluating the basic case with $n = 1$, assuming the statement was true for $n = k$ and attempting to add the $(k+1)^{\text{th}}$ term. Most students who got this far went on to show that the statement was true for $n = k + 1$, although errors were seen at this stage. Where students had successfully applied the method of induction, their conclusion was sometimes missing one or more element (often "true for $n = 1$") and the final accuracy mark was lost. A small number of students completely ignored "Proof by Induction" and used the standard formulae instead, attempting to expand the LHS and/or RHS and perform various algebraic manipulations.

In Q09(b) correct starts were made establishing that $n = 1$ gave a multiple of 18. Most then wrote down correct expressions for $\mathrm{f}(k)$ and $\mathrm{f}(k+1)$ and formed an expression for $\mathrm{f}(k+1) - \mathrm{f}(k)$, usually arriving at $3\times 4k + 6$. At this stage many asserted that this was divisible by 18 and went to a conclusion. There were some who wrote $3\times 4k + 6 = 18\left(\frac{4^k}{6}+\frac{1}{3}\right)$ "so it is divisible by 18". Students who were successful at this stage and achieved $3(4k + 6k + 8) - 18k - 18$ forgot to then obtain a final expression for $\mathrm{f}(k+1)$. There were only a small number of students who were able to achieve a correct expression for $\mathrm{f}(k+1)$ and then draw a correct conclusion. A wide range of multiples of $\mathrm{f}(k)$ were added to or subtracted from $\mathrm{f}(k+1)$ in attempts to demonstrate the divisibility by 18. A few examples were seen where the student factorised $3\times 4k + 6$ to $3(4k + 2)$ and then used a complete induction method to attempt to show that $(4k + 2)$ is a multiple of 6.

In some cases students' concluding statements suggest that they do not fully understand the principle of mathematical induction. For example "$n = 1$ is true, $n = k$ is true, $n = k + 1$ is true so true for all n" and "if $\mathrm{f}(k+1)$ is true then $\mathrm{f}(k)$ is true" were seen quite frequently. There were also some minimalist conclusions where, after correct working, the student simply wrote "so true for all n".

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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