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Examiners' Report

Summer 2016

Pearson Edexcel IAL in Further Pure Mathematics 1 (WFM01/01)

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IAL Mathematics Further Pure 1

Specification WFM01/01

Introduction

This paper was accessible to all students.

In summary, Q01, Q02(a), Q03(a), Q04(b), Q06, Q08(a) and Q09 were a good source of marks, mainly testing standard ideas and techniques and Q02(b), Q03(b), Q04(a), Q07(a), Q07(b), Q07(c), Q08(b) and Q10(i) were discriminating at the higher grades. Q07(d) and Q10(ii) proved to be the most challenging questions on the paper.

Report on Individual Questions

Question 1

This question proved accessible for the vast majority of students.

Almost all students expanded the cubic expression $r\left(r^2-3\right)$ and substituted the standard formulae for $\sum_{r=1}^{n} r^3$ and $\sum_{r=1}^{n} r$ into $\sum_{r=1}^{n}\left(r^3-3r\right)$. Students who then directly factorised out $\frac{1}{4}n(n+1)$ were usually more successful in obtaining the correct answer. Some students who expanded to give $\frac{1}{4}n^4+\frac{1}{2}n^3-\frac{5}{4}n^2-\frac{3}{2}n$ were less likely to obtain the correct answer.

Question 2

This question discriminated well across students of all abilities.

In Q02(a), most students wrote down the correct coordinates of the point *S*.

A significant minority of students struggled to synthesize the information given in Q02(b) and so made no creditable progress. Those students who made progress almost always provided a clear diagram containing a labelled triangle *ABS*. This diagram enabled them to find the *y*-coordinates at the points *A* and *B* by substituting $x = 3.5$ into $y^2 = 28x$. Most students found the area of triangle *ABS* by using the formula $\frac{1}{2}$(base)(height), although some students used an incorrect method which gave either one-half or twice the required answer.

Question 3

This question proved accessible for the majority of students. Q03(b) was often not attempted.

In Q03(a), most students differentiated $\mathrm{f}(x)$ correctly and applied the Newton-Raphson procedure correctly to give a second approximation for α as -1.67 .

In Q03(b), only a minority of students confirmed that α is -1.67 to 2 decimal places. The majority of these students usually evaluated both $\mathrm{f}(-1.675)$ and $\mathrm{f}(-1.665)$ and demonstrated a change of sign. Other successful students applied the Newton-Raphson procedure for a second time on -1.67. Incorrect methods included evaluating both $\mathrm{f}(-1.68)$ and $\mathrm{f}(-1.66)$ or just evaluating $\mathrm{f}(-1.67)$.

Question 4

This question discriminated well across students of all abilities.

In Q04(a) most students began their proof by showing that $\det(\mathbf{A}) = k^2 + 2k + 3$. There was a fairly even split between those students who elected to complete the square and those who found $b^2 - 4ac$. There was a much greater chance of success amongst those students who completed the square, the majority being able to show that $\det(\mathbf{A})$ was positive. Those who showed that the discriminant was negative, and thus $\det(\mathbf{A})$ was never zero, rarely produced a fully correct solution.

In Q04(b), most students correctly stated $\mathbf{A}^{-1}$ in terms of k. Common errors included stating $\mathbf{A}^{-1} = \dfrac{1}{\det(\mathbf{A})}\begin{pmatrix} k+2 & -3 \\ 1 & k \end{pmatrix}$ where $\det(\mathbf{A})$ had been evaluated incorrectly or stating $\mathbf{A}^{-1} = (k^2 + 2k + 3)\begin{pmatrix} k+2 & -3 \\ 1 & k \end{pmatrix}$.

Question 5

This question proved accessible for the majority of students.

Most students started this question by multiplying the numerator and denominator of the right hand side of the equation by $(7-\mathrm{i})$ to give $\frac{25+25\mathrm{i}}{50}$ with a noticeable number incorrectly simplifying $\frac{21-3\mathrm{i}+28\mathrm{i}+4}{50}$ to give $\frac{25-25\mathrm{i}}{50}$. Some students made no further creditable progress at this point mainly because they did not understand that if $z=a+b\mathrm{i}$ then $z^*=a-b\mathrm{i}$. Most students simplified $2z+z^*$ to give $3a+b\mathrm{i}$ and then proceeded to find the values of *a* and *b* by equating both the real and the imaginary parts of both sides of their equation.

Few students started this question by multiplying both sides of the equation by $(7+\mathrm{i})$. They then proceeded to solve simultaneous equations in order to find the values of *a* and *b*.

Question 6

This question proved accessible for the vast majority of students.

Most students verified the result in Q06(a) by either showing that $5t\left(\frac{5}{t}\right)=25$ or

$y=\frac{25}{x}=\frac{25}{5t}=\frac{5}{t}$ or $x=\frac{25}{y}=\frac{25}{\frac{5}{t}}=5t$ or by using their formula book to state $c=5$.

Students used a variety of methods in Q06(b) to find $\frac{\mathrm{d}y}{\mathrm{d}x}$. Most students wrote $y=\frac{25}{x}$ and differentiated this to give $\frac{\mathrm{d}y}{\mathrm{d}x}=-\frac{25}{x^2}$. Some students used implicit differentiation or the chain rule with the parametric equations. Most students were then successful in finding the equation of the normal and obtained the given result in Q06(b). A few students, who did not use a calculus method but just stated that the gradient of the normal at *A* is t^2, lost all the marks in Q06(b).

In Q06(c), most students correctly substituted $y=\frac{25}{x}$ or $x=\frac{25}{y}$ or $x=5t,\ y=\frac{5}{t}$ into the given equation. Some were unable to make further progress at this stage. The majority proceeded to form a three-term quadratic equation, which they solved to find the coordinates of *B* as $\left(-40,-\frac{5}{8}\right)$ with some incorrectly finding $\left(40,\frac{5}{8}\right)$.

Question 7

A number of students did not gain full marks in Q07(a), although most recognised that a rotation about $(0,0)$ was involved. Errors in this part included students incorrectly finding the angle of rotation or incorrectly stating the sense of the rotation.

An incorrect matrix was fairly common in Q07(b), with the non-zero entries incorrectly placed, or some variant of the matrix given in the question.

In Q07(c), the majority of students used their answer from Q07(b) to multiply two matrices in the correct order to give $\mathbf{PQ}$, but a significant number multiplied the matrices in the wrong order. Some of the more able students were able to write down the correct answer based on an understanding of the geometry.

Q07(d) was often not attempted. This was because the majority of students did not understand what mapping the straight line $y = kx$ onto itself actually meant. As a result the majority of students struggled to form a correct matrix equation in *k*. Successful students wrote down and attempted to solve a correct matrix equation such as either $\begin{pmatrix} -\frac{12}{13} & \frac{5}{13} \\ \frac{5}{13} & \frac{12}{13} \end{pmatrix}\begin{pmatrix} x \\ kx \end{pmatrix} = \begin{pmatrix} x \\ kx \end{pmatrix}$ or $\begin{pmatrix} -\frac{12}{13} & \frac{5}{13} \\ \frac{5}{13} & \frac{12}{13} \end{pmatrix}\begin{pmatrix} 1 \\ k \end{pmatrix} = \begin{pmatrix} 1 \\ k \end{pmatrix}$. These students usually obtained a correct $k = 5$ from multiplying out and solving an equation in *k*, but a significant number failed to check that $k = 5$ satisfied the second equation or failed to solve the second equation to also find $k = 5$.

Question 8

In Q08(a), almost all students wrote down the complex conjugate root $-3-8\text{i}$.

Most students used the conjugate pair to write down and multiply out $(z-(-3+8\text{i}))(z-(-3-8\text{i}))$ in order to identify the quadratic factor $z^2+6z+73$. Some students achieved this quadratic factor using the sum and product of roots method. Most students used long division to find the remaining quadratic factor, although some manipulation errors were seen at this stage. A significant number of students used various methods to determine the values of *a* and *b*, often correctly, and although this often did not prevent them reaching the correct result, it did give them some extra work. Many students achieved the second quadratic factor z^2+3, but a surprising number failed to solve $z^2+3=0$ correctly, with $\pm 3\text{i}$ or $\pm\sqrt{3}$ commonly seen.

Most students correctly plotted $-3+8\text{i}$, $-3-8\text{i}$, $\sqrt{3}\,\text{i}$ and $-\sqrt{3}\,\text{i}$ on an Argand diagram, although some did not show a scale. A minority plotted $\sqrt{3}\,\text{i}$ and $-\sqrt{3}\,\text{i}$ on the real axis. Those who had incorrectly solved the equation in Q08(b) found their roots a little more difficult to plot on their Argand diagram. A small minority made no attempt at Q08(c).

Question 9

There were the occasional algebraic, manipulation and bracketing errors seen in some students' solutions.

In Q09(a), the most common errors were 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 or deduce that $\alpha^2 + \beta^2 \equiv (\alpha + \beta)^2 - 2\alpha\beta$ and $\alpha^3 + \beta^3 \equiv (\alpha + \beta)^3 - 3\alpha\beta(\alpha + \beta)$ or $\alpha^3 + \beta^3 \equiv (\alpha + \beta)(\alpha^2 + \beta^2 - \alpha\beta)$. Some students wrote down and applied $\alpha^3 + \beta^3 = (\alpha + \beta)^3$. Those students who wrote down $\alpha + \beta = -2$ and $\alpha\beta = -\frac{3}{2}$ and used the correct identities usually found the correct values for $\alpha^2 + \beta^2$ and $\alpha^3 + \beta^3$. A small minority of students, who did not read the instruction given in Q09(a), found $\alpha, \beta = \frac{-4 \pm \sqrt{40}}{4}$ and so scored 0 marks in this part.

In Q09(b), the new sum and product were often calculated correctly but the main source of error was in forming the new quadratic equation. The three main errors in establishing the required quadratic were applying the incorrect method of $x^2 + (\text{sum})\,x + \text{product}$, the omission of "= 0" and not giving integer coefficients.

Question 10

In Q10(i), a significant number of students failed to demonstrate that the general result was true for $n = 1$ by showing either $u_1 = 2(3) - 1 = 5$ or $u_1 = 6 - 1 = 5$. The majority substituted $u_k = 2(3)^k - 1$ correctly into $u_{k+1} = 3u_k + 2$ and manipulated their expression to give $u_{k+1} = 2(3)^{k+1} - 1$.

In Q10(ii), a significant number of students failed to show or state that for $n = 1$, both the LHS and RHS of the general statement were both equal to $\frac{4}{3}$. A significant minority of students did not produce any creditable work after this stage. Although just over half of the students correctly added the $(k+1)^{\text{th}}$ term to the sum of k terms to give $\sum_{r=1}^{k+1} \frac{4r}{3^r} = 3 - \frac{(3+2k)}{3^k} + \frac{4(k+1)}{3^{k+1}}$, only a minority manipulated this to give $\sum_{r=1}^{k+1} \frac{4r}{3^r} = 3 - \frac{(3+2(k+1))}{3^{k+1}}$.

In Q10(i) and Q10(ii), some students did not bring all strands of their proof together to give a fully correct proof. A minimal acceptable proof, following on from completely correct work, would incorporate the following parts: assuming the general result is true for $n = k$; then showing the general result is true for $n = k+1$; showing the general result is true for $n = 1$; and finally concluding that the general result is true for all positive integers.

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