Examiners' Report

Summer 2016

Pearson Edexcel GCE in Further Pure Mathematics 1 (6667/01)

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GCE Mathematics Further Pure 1

Specification 6667/01

Introduction

The paper was accessible to all students, with methods well known and accurately executed. The work was generally well set out so that it was not difficult to follow the working. There were very many completely correct solutions to the first 5 questions, but questions 6, 7, 8 and 9 proved more demanding. However, students were typically able to start and make some progress on all questions.

Report on individual questions

Question 1

The majority of students knew the definition of a singular matrix and got this question completely correct. A few were unable to find determinant accurately, but many found the correct determinant and equated to zero and succeeded in obtaining a fully correct solution. The most commonly seen errors were, having arrived correctly at $k^2 = \frac{1}{2}$, proceeding to give the positive root only. Unfortunately, $k^2 = \frac{1}{2}$ producing a solution of $k = \pm\frac{1}{4}$ was not a rare occurrence.

Question 2

Differentiation was almost always correct in Q02(a) but there were errors in arithmetic, usually in the derivative including sign errors and index errors when differentiating $x^{-\frac{1}{2}}$

In Q02(b) students were able to apply Newton-Raphson and the majority of students were successful in gaining full marks. However, errors did occur, particularly when carrying out a lot of calculations. In order to avoid the loss of too many marks when an error occurs, students should also write down the values of $\mathrm{f}(\alpha)$ and $\mathrm{f}'(\alpha)$, α being 12.5 in this instance. Some students did not show working and rounded to 3 significant figures not 3 decimal places, which doesn't provide evidence of correct working without intermediate steps.

Question 3

The majority of students answered Q03(a) correctly. Errors were mainly due to not replacing all the *n*'s with 3*n*. The first was usually correct so the most common error seen was $\frac{1}{6}(3n)(n+1)(2n+1)$.

Very many fully correct solutions were seen from students in Q03(b) who were successful in Q03(a). Some students made life difficult by failing to take a factor of $\frac{n}{6}$ out at the start of their work; they should be encouraged to use the given solution as a guide to finding common factors and deal with these straight away. Students were usually able to expand each term to obtain quadratic expressions, this being done to a high degree of accuracy. A few errors were made with coefficients, but the main cause of any errors was that of making a sign error when subtracting the second term.

Question 4

The techniques required for Q04(a) were well known and errors were usually errors in the expansion of brackets, eg $-2\text{i} \times -2\text{i} = -2$

The students who squared their answer to Q04(a) for Q04(b) gained a high degree of success here, although there were a few errors in the expansion for a tiny minority. Students who chose to square the given expression for z were less successful as greater care was needed when using this approach.

The most popular approach taken to finding p and q in Q04(c) was to expand $(x-z)(x-z^*)$ using their z from Q04(a). Errors, when they occurred, were usually errors in the expansion of brackets although a tiny minority did attempt to expand $(x+z)(x+z^*)$ with unfortunate results. A small minority of students elected to substitute their z and z^2 into the given equation and then equate real and imaginary parts, usually with a high degree of success. The approach that caused the greatest number of errors was that of using sum and product of roots. The major cause of problems was saying that p = (sum of roots), forgetting the essential minus sign.

Question 5

The majority of students found the correct gradient in Q05(a) and substituted into the correct linear format. However a sizeable minority failed to simplify their gradient from $\frac{2ap-2aq}{ap^2-aq^2}$ to $\frac{2}{p+q}$, which made simplification of their equation much more complicated. Those students who did this typically failed to successfully produce a convincing argument.

Q05(b) was usually completely correct.

In Q05(c) a completely independent part of the question meant that those who experienced problems in Q05(a) were still able to be successful here. Explicit, implicit and parametric differentiation were all used highly effectively and most students obtained to correct gradient of $\frac{1}{p}$.

In Q05(d) a large majority of students correctly used $\frac{1}{q}$ as the gradient at Q and many were able to produce a convincing argument that the tangents were perpendicular. However a minority, who clearly knew why they were perpendicular, were unable to express their argument clearly and with confidence.

Question 6

Many correct solutions were seen to Q06(a) and nearly all students recognised this as a rotation matrix. The most common error was to be omission of the centre as part of their description.

A few students used an angle of 45° instead of 135° and even fewer used the wrong direction of rotation. Most students obtained the correct solution in Q06(b). The most popular approach was to use $\mathbf{P}\begin{pmatrix} p \\ q \end{pmatrix} = \begin{pmatrix} 6\sqrt{2} \\ 3\sqrt{2} \end{pmatrix}$, multiply out and solve the resulting simultaneous equations. Any errors were caused by incorrect manipulation of the surds.

A minority did take the more straightforward route of finding the inverse of matrix **P** and pre-multiplying the position vector $\begin{pmatrix} 6\sqrt{2} \\ 3\sqrt{2} \end{pmatrix}$ by it to directly produce values for *p* and *q*.

A majority of correct matrices were seen in Q06(c). A tiny number used identity matrices or else –1 instead of 1.

Mostly correct products found in Q06(d), although a minority did find **PQ** instead of **QP**.

Many students did not fully understand "self-inverse" in Q06(e) and simply found the determinant as a sufficient argument. The most popular successful approach was to find $\mathbf{R}^{-1}$ and show it was the same as **R**. Some students successfully showed that $\mathbf{R}^2$ was the identity matrix.

Question 7

Many students gained full marks for Q07(a). Mostly correct expressions for $z^2 + 2z$ were seen, bar the odd error. The most common loss of marks was caused by a failure to separate real and imaginary parts, as requested in the question.

Some confusion was evident in Q07(b) showing, in some cases, a minority erroneously equating the real part to zero. The majority did equate their imaginary part to zero and find $a = -1$.

The approach of most students was correct in Q07(c) and those with a correct answer to Q07(b) were usually successful. If a mistake was made in Q07(b) students would usually achieve one mark for getting their *P* in the correct quadrant, sometimes gaining the follow through for their *R*. The majority having produced a correct Q07(b) went on to get full marks on this part.

Many students spotted that the lines were parallel in Q07(d), but failed to notice that *QR* was twice the length of *OP*. A minority did spot an enlargement with scale factor 2 but very few of them progressed to a correct translation.

Question 8

In Q08(i) most students were able to successfully show that the summation was true for $n = 1$. However, many did not make that statement at this stage but left it for the final conclusion. The majority of students did appreciate how to approach the formal proof. However, having correctly added $\frac{2(k+1)+1}{(k+1)^2(k+2)^2}$, a large number of students became very confused with the minus signs when combining the fractions and in some cases decided, unnecessarily, to incorporate the lone 1 into their fraction. Many of the rest made the decision to change the order of terms, so that the positive fraction was first, before combining fractions. This produced far fewer errors.

Most who achieved a correct combination of fractions did take a final step of rewriting in terms of $k+1$. Students typically knew how to approach the recurrence relation in Q08(ii). That does not mean that they were all successful. Many students failed to show enough detail to be convincing. Most were able to verify the truth of the statement for $n=1$, however some did work with $n=2$ only which caused problems with the final statement. Some were not thorough enough in their working in the main stages of the proof when aiming for $5\times\left(3\right)^{k+1}+\frac{4}{3}$, leaving out essential steps, in particular the addition of $\frac{8}{9}$. Some students attempted to work backwards but were, generally, not fully convincing in their argument.

Question 9

Q09(a) was done well. As in Q05(e), the expression obtained for the derivative was equally likely to have come from explicit, implicit or parametric differentiation. With hardly any exceptions, students substituted p and used the negative reciprocal to find a gradient of p^2 for the normal. A correct substitution then successfully confirmed the given equation.

The first step in Q09(b), of substituting into the normal equation from $y=-x$, was taken correctly by the majority of students. However some omitted the factorisation stage which is essential in a "show that" question. Fully successful students mainly factorised $\left(1-p^4\right)$ as $\left(1-p^2\right)\left(1+p^2\right)$ and cancelled terms in order to produce the required coordinates. A few used long division successfully. Hardly any students used the approach of verifying that the given coordinates satisfied both equations, but a few were successful this way.

Q09(c) was challenging for many students. Some did not know how to find the coordinates of a midpoint. Of those who did, many failed to find both coordinates and in some cases equated the x-coordinate to zero. Some students did realise that M was on the normal and were able to equate two expressions for the x-coordinate in order to find p.

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