Examiners' Report

Summer 2015

Pearson Edexcel GCE in
Further Pure Mathematics FP2
(6668/01)

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Mathematics Unit Further Pure 2

Specification 6668/01

General Introduction

This was a reasonably straightforward paper which gave all students plenty of opportunity to show their knowledge of the specification. There were no obvious signs that students did not have sufficient time to complete all the work they were able to do.

Students have regularly been advised in many previous reports to write down the formula that they are going to use. More are doing this but it still needs to be stressed the advantage is to write down the formula before using it. Errors in substitution are then penalised by accuracy marks only; if the general formula is not shown then method marks are lost as well.

Some students are clearly spending a long time on relatively short questions such as number 3. Time management is part of examination technique and students should move on if they feel they are not succeeding with a question; they can return at the end if they have time left.

Examiners reported several instances of poor handwriting which made it extremely difficult to determine the variable being used. This was particularly seen in question 8 with u, y and even x all looking very similar. Also it was sometimes difficult to distinguish between powers and multiples in some students' presentation.

Report on Individual Questions

Question 1

Many students were able to achieve full marks in part (a) on what is essentially a very standard question. Those who completed the question successfully in an efficient manner, chose to either (i) multiply through by $(x + 3)^2$ and rearrange or (ii) subtract $\frac{12}{x+3}$ and rearrange to form a single, factorised fraction. Of those who opted for method (i), some failed to spot that there is an $(x + 3)$ factor in both terms and then wasted time by multiplying out to form a cubic which they then had to factorise. This often resulted in errors. The most common errors occurred following multiplication by $(x + 3)$ initially rather than the bracket squared, as they rarely considered the effect on the direction of the inequality either side of $x = -3$ Some students chose to draw a graph or a table to help them to identify the correct inequalities - a large number of students, though, were able to do this without either.

Some students still interpret "using algebra" to mean only using algebra. An algebraic rearrangement to identify all 3 critical values is all that is required. Many students wasted time by then considering sets of values to work out their final inequality. Those who realised a graphical approach is acceptable here, once critical values had been identified, were usually able to identify the required inequalities efficiently. Students who graphed both sides of the original inequality were in a better position to answer part (b) as they could quickly identify which parts of the graph would now be positive. Those who had drawn resulting cubics and other expressions either proceeded to get part (b) wrong or had to draw a second graph, wasting time. Many students felt the need to justify their answer to part (b), when for a single B mark, $x > 1$ was all that was required. Many responses just restated the inequalities found in (a).

It was worrying to note the small minority of students at this level who gave $-3 < x < -6$ as one of their inequalities. $-3 > x > -6$ also occurred and whilst correct, is inelegant, and surprising from Further Mathematics students.

Question 2

All students were able to attempt part (a), with $|z| = 4$ found in most responses. Virtually all students gained the M mark for using tangent and considering quadrant and most gained full marks for a correct argument; $-\pi/3$ was the most common incorrect argument.
Almost all students were able to attempt part (b) but a significant number did not simplify their answer with $4096(\cos 4\pi + i \sin 4\pi)$ being a common final answer.

Part (c) was answered poorly in relation to (a) and (b). The majority of students preferred to find z^3 first and then find the fourth root. A significant proportion applied de Moivre's theorem and were able to find a single root but most struggled to find a correct general argument. Many added $2k\pi$ after applying de Moivre or simply were unable to substitute values of k correctly. A significant proportion only found 1 further root and so did not gain the M mark. Surprisingly few students found further roots using symmetry.

Question 3

The first 3 marks were obtained by many students using an appropriate method. The most common error here was obtaining the integrating factor as cos x.

To integrate the RHS, good students spotted that using $2\cos^2\theta - 1 = \cos 2\theta$ gave an integrable function and obtained the required solution in two or three lines. Some correctly integrated by parts once and then used the $\cos 2\theta$ substitution and a smaller number correctly used a factor formula. It was rare to see students correctly using a reduction approach. A common response was to attempt integration by parts and to give up after one application. Those who didn't give up battled on usually obtaining an incorrect integral although many students tried several approaches before abandoning the effort.

Question 4

This question really tested the students mathematical communication skills and many were let down by poor notation and a lack of reasoning. In part (a) most students were able to prove the given result. The majority opted to expand the two pairs of brackets first and then either multiply by r^2 and simplify, or factorise the r^2 out of the expression before simplifying. A small number used the difference of two squares. Many students did not gain full marks for part (b). Some students treated the identity as if it were an equation and started by dividing throughout by r^2. Although some students made no attempt to apply the method of differences most made some attempt to list terms. Of those who were listing the correct terms some did not list sufficient terms to demonstrate that cancelling would occur, in particular, students had a tendency not to write down a complete result for $r = n$. The next stage of the process was to extract the terms which had not cancelled out, most students were able to do this correctly although some did not explicitly state $n^2(n+1)^2$ and others wasted time expanding this result which was not a necessary step.
The students who had been listing terms without considering the LHS of the process often reached this stage and did not know how to continue, others made mistakes expressing the LHS showing a general uncertainty about how to deal with the $\frac{1}{4}$. If they had been considering the LHS throughout then it was a simple case of dividing throughout by 4 to reach $\sum r^3 = \frac{n^2(n+1)^2}{4}$.
It was the final step of the proof that proved most problematic as many students ended the proof with $\sum r^3 = (\sum r)^2$ when they were actually asked to show that

$(1^3 + 2^3 + 3^3 + \ldots + n^3) = (1+2+3+\ldots+n)^2$. A conclusion which was omitted by many.

Question 5

In part (a) most students rearranged the equation successfully to make w the subject and used $|z| = 2$, gaining the first three marks. Many students demonstrated excellent algebraic skills and worked through this question very well, achieving the full 8 marks in part (a). Common errors were forgetting to square either the 2 or the 3 when finding the modulus and these lost all the subsequent accuracy marks. Those who incorporated terms in i when attempting to find the modulus lost the remaining five marks in (a) as their subsequent equation did not represent a circle. Some students began by using $z = x+y\text{i}$ and found an expression for w, which they then multiplied by the complex conjugate of their denominator in order to make the denominator real. However, very few got beyond this point as they were unable to see how to use $|z| = 2$ in this context. Most of those who obtained a circle equation went on to complete the square to find the centre and radius, although there were often sign and computational errors seen. Many lost a mark by failing to conclude explicitly that their equation represented a circle.
In part (b) most got the follow through mark for drawing a circle on an Argand diagram that was correctly placed for their centre and radius. The last mark required the correct circle to have been drawn so was not accessible to those who had made errors earlier. A surprising number of students shaded the outside of the circle rather than the inside and

few gave any reason for their decision. Few thought to use the coordinates of the centre of the circle to find whether it was in the region required.

Question 6

This question was very well answered. In both parts of the question the majority of students knew the methods needed to solve the problem and were able to apply them accurately and with good use of mathematical notation. Those who did struggle with part (a) were still able to achieve some marks in part (b).

In part (a) very few students were not aware that they needed to differentiate $y = r\sin\theta$ and almost all did so correctly, using correct trigonometric identities to form the correct quadratic in $\cos\theta$. Most students who lost marks in this part of the question did so at this stage, by incorrectly factorising their quadratic. Having solved their quadratic to obtain $\cos\theta$ and hence θ, it was uncommon but not unseen for students to forget to evaluate the value of r.

In part (b) the formula for area was used confidently and the majority of students were able to manipulate r^2 into an integrable form using the double angle formula for cosine. The most commonly seen errors in this question were 'slips' such as evaluating r^2 as $3a(1 + \cos\theta)^2$ or $3a^2(1 + \cos\theta)^2$, getting a sign wrong in the double angle formulae, or integrating cosine to obtain negative sine. Of those who did successfully integrate r^2, some struggled to then correctly evaluate and simplify their answer at $\pi/3$.

Question 7

Part (a) of this question tested the ability of the students to differentiate $\sec^2 x$ twice. The first derivative was achieved correctly by most students using the chain rule. The required expression for the second derivative could be obtained in two ways both of which involved the use of $\sec^2\theta = 1 + \tan^2\theta$. Most students chose to differentiate the first derivative as it stood rather than to re-write it solely in terms of $\tan x$ first. There were instances of sign errors in the identity used but the purpose of giving the answer was to give a chance for the students to recover from such errors.

It was very rare for students to use their incorrect answer to part (a) to proceed in part (b). Solutions were usually sound although sign errors did re-occur in some solutions. Part (c) tested the students' ability to take the information that they had already got and to use it to generate a Taylor series in powers of $(x - \pi/3)$. Only a few students gave an expansion in powers of x rather than $(x - \pi/3)$ and a similar small proportion did not expand as far as necessary. The idea of having to evaluate y and its three derivatives at $\pi/3$ was well known and applied with a few students using $-\pi/3$ in error. The final mark was lost by students who otherwise had a perfectly good solution by either writing the answer as "f(x) =…." where there had been no prior definition of the function f or by the omission of the $\sqrt{3}$ in the coefficient of the $(x - \pi/3)^3$.

Question 8

Part (a) was a challenging question for many students although it was also pleasing to see some deal with it with a minimum of fuss. The first derivative was usually found quickly, easily and correctly; it was the second derivative that caused the majority of problems. Almost everyone who attempted the second derivative realised the product rule would be required but some failed to use the chain rule as well and then struggled to make further progress. Some students also tried to work with the square of their first derivative rather than a second derivative. There was also evidence of many students adjusting their previously incorrect working (scribbling out, over-writing and squeezing in extra variables) to try to get to the given result although these sometimes gained full marks if all terms were adjusted appropriately.

Students generally did considerably better with part (b) and it was good to see so many who had struggled with part (a) succeed here. A few students derived the auxiliary equation rather than simply writing it down but most examples of this were completely correct. Forming and solving the auxiliary equation seemed to be well within students' comfort zone and the vast majority achieved $m = 4$ and then produced an acceptable expression for the complementary function which usually appeared in factorised form although occasionally as two separate terms.

When attempting the particular integral most students knew what was involved and started with an appropriate linear expression although there were several examples of careless algebra and calculation errors which meant that the correct coefficients could not be obtained. A typical error would be starting with $y = au + b$, getting to $16a = 2$ and stating that $a = 8$. A more serious error was students' use of $y = au$ or other equivalent linear expressions without constant terms. This was seen far too often. Students were familiar with the need to combine their complementary function and particular integral to obtain a general solution and therefore many received the B1ft mark.

Those students with a correct general solution in part (b) usually gained the B1 mark in part (c) unless they were particularly careless. For the others, any earlier error usually meant this mark was impossible to achieve although a few did manage to recover from mixed variables in an otherwise correct expression in part (b) to form a correct expression in (c).

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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