Examiners' Report
Principal Examiner Feedback

Summer 2017

Pearson Edexcel GCE
In Further Pure Mathematics FP3 (6669/01)

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General introduction

In general there was a very wide range of mathematical ability displayed.

The examination gave plenty of opportunities for candidates to use and apply their mathematics effectively. There were some excellent attempts at the paper resulting in full marks in many questions. However, it should be noted that candidates should take particular care in 'show that' questions, where examiners are expecting to see all the required steps necessary to establish a particular result.
Candidates should also be encouraged to check their work if they have time. This was particularly relevant in question 6(b), where a minor slip at the start when finding the inverse matrix, could result in the loss of several marks.
Questions that discriminated well were 3(b), 4, 7 and 8.

Question 1

This question required a given derivative of $y = \text{arsinh}(\tanh x)$ to be shown. Those who proceeded to $\sinh y = \tanh x$ followed by implicit differentiation were invariably successful, although a small number used an incorrect hyperbolic identity when attempting to express $\cosh y$ in terms of x. Some candidates were also a little careless with their presentation. For example, $\text{sech}^2 x$ becoming $\sec^2 x$ in the middle of their work or variables being omitted, which often resulted in the loss of the final mark in this 'show that' question. Students who used the chain rule were expected to make this explicit by introducing a third variable. A very small number elected to integrate. Use of the logarithmic form of arsinh was very rare and produced mixed results due to this route's awkward algebra.
Some candidates effectively wrote down the result in the question with no explanation apart from 'detaching' the numerator from the denominator. In these cases a special case was allowed of 2 marks as credit for an incomplete attempt to demonstrate an application of the chain rule.

Question 2

Part (a) required students to obtain the equation of the normal to an ellipse and almost all students scored well here with this routine work. Parametric differentiation was the sensible choice although correct implicit differentiation was widely seen and in a significant number of cases, explicit differentiation, which was less efficient. The required perpendicular gradient rule and straight line methods were almost always applied correctly and the printed answer was obtained with no errors by the vast majority.
Part (b) was more discriminating, although many fully correct proofs were seen. It was common to see the correct x coordinate for Q but some were confused in their attempts to find OR, with some students believing that Pythagoras' theorem was required. A simple sketch of the situation proved useful to many. Those who realised the need for an eccentricity formula almost always used the correct one, although errors were occasionally seen in obtaining the value of e^2. A small number thought that use of the foci and/or directrices was necessary and were rarely able to get back on the right track.

Question 3

Part (a) was confidently handled by almost all students. Most substituted into the right hand side of the identity and errors such as using an incorrect exponential form were rare. A smaller number began with the left hand side which required completion of the square but this was usually completed correctly. Only a small number failed to use the definition for $\cosh x$ in terms of exponentials.
Part (b) was a good source of marks for the majority of candidates. The correct quadratic in $\cosh x$ was almost always obtained and solved correctly. The logarithmic form of arcosh was then used to obtain answers although the two negative solutions were often absent. Using the exponential form of $\cosh x$ to produce a quadratic in e^x was also common and despite the extra work involved, this approach did increase the chances of all four solutions being obtained. Those who used exponentials in the original equation usually reached a correct quartic in e^x but further progress was rare.

Question 4

This integration by substitution question proved to be discriminating. Almost all students were able to transform the integral from one in x to one in u correctly. However, many did not appreciate that the integrand was an improper fraction and splitting it was necessary to proceed and so made no further progress although the B marks for the correctly changed limits was still available and scored by many. Those that could split the fraction usually went on to integrate correctly and score full marks. However, many candidates made failed and lengthy attempts at integration by parts once they had correctly reached $\int \frac{2u^2}{u^2+3}\,\mathrm{d}u$. A significant number of candidates chose to make a second substitution such as $u = \sqrt{3}\tan\theta$ and often went on to complete correctly.

Question 5

There was a wide range of mark profiles awarded for this vector question but many completely correct solutions were seen. In part (a), many students made a complete attempt to find $\cos\theta$ and slips in the use of $\boldsymbol{a}.\boldsymbol{b} = |\boldsymbol{a}||\boldsymbol{b}|\cos\theta$ were rare. The alternative route using $\boldsymbol{a} \times \boldsymbol{b} = |\boldsymbol{a}||\boldsymbol{b}|\sin\theta$ was only occasionally seen. The last mark was withheld if the answer was not given to the nearest degree or for incorrect subsequent working such as subtracting the answer from 90° or 180°.
The correct parametric form of PQ was usually obtained in part (b) and invariably substituted into the correct plane equation. Those who used the wrong plane or had obtained the wrong value of the parameter were still able to access all the marks in part (c). Slips when solving the equation in λ or substituting its value back into the parametric form were fairly common.
In part (c), a cross product of normals was attempted by most with alternatives for generating the normal to Π_3 rarely seen. Sign errors (often 14 instead of -14 for the y component) were common. Many then proceeded to calculate $p = \boldsymbol{a}.\boldsymbol{n}$ with only a small number producing a vector rather than a scalar on the right hand side of their plane equation.

Question 6

In part (a) of this matrix question, full marks were almost always awarded. The method for calculating the determinant of a 3 x 3 matrix – usually by using row 1 – was widely known and slips were rare.
Most students demonstrated a full method for the inverse in part (b) although there were a few cases of one or more missing steps. It was very unusual to see the determinant missing although $1 - 2k$ rather than $\frac{1}{1-2k}$ was occasionally seen. Sign and copying errors were common.
Part (c) was more demanding. Most realised that l_2 was required in parametric form and the correct vector in λ was widely obtained. Multiplying by $\mathbf{M}^{-1}$ usually followed, with slips in the matrix multiplication (or use of an incorrect inverse) occasionally costing students a couple of accuracy marks. A small number neglected to convert their resulting parametric form back into Cartesian form or made slips during the process. It was rare to see this method carried out without an explicit parameter. Alternative methods, such as using $\mathbf{M}l_1 = l_2$ and solving simultaneous equations, were rare and when seen, usually led to errors.

Question 7

As with most previous questions on reduction formulae, this proved to be discriminating although many clearly presented correct solutions were seen. In part (a), those who wrote $cosh^n x$ as $cosh^{n-1}x\ cosh\ x$ usually made progress, although many differentiated $cosh^{n-1}x$ incorrectly as $(n-1)\ cosh^{n-2}x$, causing their method to break down. Students who obtained the $sinh^2 x$ usually replace it correctly with $cosh^2 x - 1$ and proceed to the correct solution. A small number lost the last mark – usually due to sign errors or by not giving their answer in the form required by the question. An alternative – to write $cosh^n x$ as $cosh^{n-2}x\ cosh^2 x$, use $cosh^2 x = 1 + sinh^2 x$ and then integrate by parts – was less common.
Unusually for a reduction formula proof, the given answer included constants that had to be found. Part (b) was a “Hence, or otherwise” which allowed students to attempt the integral by direct integration. Direct attempts at I_4 were very rare either by use of hyperbolic identities or exponentials. There were more attempts at I_2 following one application of the reduction formula which were often successful. The vast majority, however, attempted to use the reduction formula twice. This was also permitted in terms of their values of a and b or the letters a and b for three of the four marks. Many slips were seen with these applications. I_0 was usually obtained correctly as ln 2, but values of 1 and 0 were also seen.

Question 8

The final question on finding an arc length proved quite challenging but was still a good source of marks for many students. In part (a) there were a lot of possible routes available but the most common was to combine the chain and quotient rules. This was sometimes performed via implicit differentiation after taking exponentials of both sides first. Those who wrote the quotient as a product gave themselves slightly more algebra to manipulate. An elegant method was to first apply the subtraction law for logarithms and this was commonly seen. The remaining three other methods described in the mark scheme were all seen but in no great number. Generally, students who had identified and carefully constructed a full method to obtain $\frac{\mathrm{d}y}{\mathrm{d}x}$ largely scored all four marks although occasional slips with signs and/or powers were seen.

In part (b), the correct arc length formula was commonly used and it was pleasing to see many students dealing confidently with the algebra, removing the square root and obtaining the required integral. The second half of the task was more testing and some students failed to make an attempt at integration. Those who identified the integrand as $\coth x$ usually proceeded to full marks. A common error was to replace the integrand with $\tanh x$. Many other routes were possible, including rewriting the integrand into other forms that allowed for direct integration. This was rarely seen and more popular alternatives were attempts at substitutions for e^x, e^{2x}, $e^{2x}+1$ or $e^{2x}-1$. These approaches all required partial fractions but students who persevered and changed limits correctly were often successful.

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