# Examiner's Report
# Principal Examiner Feedback

## Summer 2018

Pearson Edexcel International A Level
In Further Pure Mathematics F3
(WFM03/01)

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This was a well balanced paper on which students at all levels could demonstrate their knowledge. Almost all students could start most of the questions even if they could not complete them. Question 8 was unusual in this as it was part (a) which gave rise to most problems but part (b) allowed weaker students to gain some marks.

Structure style and clarity varied widely in the solutions offered. A number of students offered solutions in tiny almost illegible script rendering it very difficult to discern their solution. Complicated algebraic fractions crammed into densely packed lines did not help clarity. Standard formulae were generally not quoted before being applied and some of those used were clearly wrong.

**Question 1**

Most students could make progress on this question and a high proportion of fully correct solutions were seen. The preferred approach was using the identity $\text{sech}^2 x = 1 - \tanh^2 x$ to form and solve a quadratic in tanh*x*. A number of students wrote down the formula incorrectly thus losing all the accuracy marks. Solving the equations $\tanh x = -\frac{1}{5}$ or $\frac{2}{3}$ was frequently done from first principles using exponential formulae for sinh*x* and cosh*x* rather than using $\text{artanh}\, x = \frac{1}{2}\ln\left(\frac{1+x}{1-x}\right)$ as given in the formula book.

Students who preferred to use exponentials from the beginning found it more challenging and errors such as $\text{sech}^2 x = \frac{2}{e^x + e^{-x}}$ were seen on a number of occasions. Solutions which initially multiplied by $\cosh^2 x$ before using exponentials found the algebra easier. Algebraic errors left a number of students unable to obtain a three term quadratic equation. Solving for $e^{2x}$ made this way easier to find values for *x*.

**Question 2**

Almost every student was able to form and solve the characteristic equation in (a) correctly with a small number missing the $"-4"$ and most then completed correctly. It was noticeable that a minority, having reached the relationship $y = 2x$, then gave the eigenvector as $\begin{pmatrix}1\\2\end{pmatrix}$.

Most of those who answered part (a) correctly then proceeded to score both marks in part (b). A small number having written down **P** then used matrix multiplication to find **D** rather than simply writing the matrix using their eigenvalues. A small number of students did not give normalised eigenvectors in (a) but did go on to normalise their eigenvectors from (a) and provide suitable **P** and **D** in (b).

**Question 3**

This was either very well answered or very poorly. By far the most common method was Way 1 with a small number using Way 2 and with only a very small minority using the quotient rule incorrectly. The most common error was to differentiate the arctan part and forget to multiply by the derivative of $\left(\dfrac{\sin x}{\cos x - 1}\right)$. Having completed the differentiation, the simplification of the fractions did cause problems at times.

**Question 4**

Differentiation of the Cartesian equation and the parametric equations to find $\dfrac{\mathrm{d}y}{\mathrm{d}x}$ were equally popular and few errors were made. Students who simplified $\dfrac{b\sec^2\theta}{a\sec\theta\tan\theta}$ initially to obtain $\dfrac{b}{a\sin\theta}$ generally found the later algebra easier. Writing down the equation of the normal was well done though a small number of students wrote down the tangent equation. Most solutions managed to manipulate their normal equation correctly to reach the printed answer.

Calculation of the intersection of this normal with the *x*-axis (point *Q*) generally caused no problems. There was no requirement to simplify the trigonometry but students who did generally found later parts of the question easier. Finding the mid-point, *M*, of the line from a point on the hyperbola to *Q* was generally successful though a few solutions subtracted the *x* coordinates. Final answers for *M* were of varying degrees of complexity thus causing problems later.

Part (c) was a discriminator with a high proportion of students not attempting or making little progress in converting the parametric coordinates of *M* into a Cartesian equation. Making $\sec\theta$ and $\tan\theta$ the subject of the equations was the easiest method but using an incorrect version of $1+\tan^2\theta = \sec^2\theta$ was a costly error for a number of students. A few solutions used $\sin^2\theta + \cos^2\theta = 1$ though this resulted in more work. Making $y^2$ the subject of this equation was challenging (or ignored) for many and final answers varied in the amount of simplification shown.

**Question 5**

Part (a) was very well answered with the vast majority of students scoring all 5 marks. Failing to score full marks was usually due to a sign error resulting in having a 5 in place of the 35.
Part (b) on the other hand was poorly answered. Most solutions correctly substituted $k$ = -1 into their inverse matrix. Very few students attempted to form a parametric form and so made no further progress as a result. Even those who were able to get the $x$ and $z$ coordinates expressed correctly in parametric form in terms of one variable often then wrote that the $y$ coordinate was zero rather than expressing it in terms of another variable. Those choosing a correct parametric form of a point on $\Pi_2$ usually transformed it successfully but were then unable to convert their parametric form of a plane into a Cartesian one. The most common misconception seemed to be that applying the inverse transformation to the normal to the plane $\Pi_2$ would result in the normal to plane $\Pi_1$.

**Question 6**

Differentiation of $x = \theta - \tanh\theta$ and $y = \text{sech}\,\theta$ with respect to $\theta$ was generally successful though $-\text{sech}^2\theta$ and $+\text{sech}\,\theta\tanh\theta$ were seen. A few students used a variable $x$ for $\theta$ in their answers. The correct surface area formula was generally used and most students substituted their derivatives correctly. A number of students found the simplification to $\text{sech}\,\theta\tanh\theta$ quite challenging.

A few solutions used the $2\pi\int y\sqrt{1+\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2}\,\mathrm{d}x$ approach but then failed to replace $\mathrm{d}x$ with $\left(\frac{\mathrm{d}x}{\mathrm{d}\theta}\right)\mathrm{d}\theta$. Quite a few solutions wrote $\int \text{sech}\,\theta\tanh\theta\,\mathrm{d}\theta = \text{sech}\,\theta$ and were unable to explain why the final answer was $-0.8\pi$.

A few examples were seen where $2\pi$ was used as one of the limits. Some students need to show more working when evaluating their limits so that, in particular, the correct use of the limit $x = 0$ is evident.

**Question 7**

Many students scored all 6 marks in part (a). Those who used Way 2 were almost always correct. It was noticeable that many students obtained a correct equation in vector form but could not convert this to Cartesian form.

Part (b) was very well understood and answered. Almost every student scored at least the method marks here.

Part (c) was also generally very well understood and answered. A small minority of students appeared to know that the scalar product was required but used sine in place of cosine and some students used the normal to the plane rather than the direction of their line and so were looking for the wrong angle.

**Question 8**

A large number of students made no progress as a result of splitting the integrand as $x^n$ and $\frac{1}{\sqrt{x^2+k^2}}$. Students splitting as $x^{n-1}$ and $\frac{x}{\sqrt{x^2+k^2}}$ generally applied the integration by parts method correctly. The next hurdle was to write $\sqrt{x^2+k^2}$ as $\frac{x^2+k^2}{\sqrt{x^2+k^2}}$. Solutions which managed this generally continued to produce a fully correct solution. A few students copied the answer from the question when it bore no resemblance to preceding work.

Evaluation of $I_5$ was attempted by most students in part (b) but sometimes careless arithmetic led to the wrong fractions in the formula linking it to $I_3$. The problem was overcomplicated by some students not writing $k = 1$ at the beginning.

Students who approached in the order $I_5$, $I_3$ $I_1$ generally proceeded well until they evaluated $I_1$; $\sqrt{x^2+1}$ was often not achieved. Evaluation of $I_1$ was frequently seen as $\sqrt{2}$ with the use of lower limit $x = 0$ omitted. Combination of the various results frequently had bracketing errors and so only a few solutions reached a final answer of $\frac{7\sqrt{2}}{15}-\frac{8}{15}$.

Students working in the order $I_1$, $I_3$ then $I_5$ often ended up substituting limits twice into part of the expression.

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