Pearson Edexcel

Examiner's Report
Principal Examiner Feedback

Summer 2018

Pearson Edexcel GCE Mathematics
In Further Pure (8FM0_21) Paper 21

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Introduction

This paper was generally accessible and there were plenty of opportunities for a typical E grade student to gain some marks across all questions. There were some testing questions involving coordinate geometry and inequalities that allowed the paper to discriminate well between the higher grades.

In a significant number of cases, students' solutions, particularly to Q5, proved difficult to read. This was a result of either poor handwriting, incoherent working or disorganised presentation.

In summary, Q1, Q2(a) and Q4(a) were a good source of marks for the average student, mainly testing standard ideas and techniques, whereas Q2(b), Q3, Q4(b) and Q5(a) were discriminating at the higher grades. Q5(b) proved to be the most challenging question on the paper.

Question 1

This was an accessible question with some students losing the final mark in part (b).

In part (a), most students recalled $\sin x = \frac{2t}{1+t^2}$ and $\cos x = \frac{1-t^2}{1+t^2}$, where $t = \tan\left(\frac{x}{2}\right)$ and substituted these into the given $5\sin x + 12\cos x = 2$. Nearly all students correctly manipulated $5\left(\frac{2t}{1+t^2}\right) + 12\left(\frac{1-t^2}{1+t^2}\right) = 2$ to give the required result $7t^2 - 5t - 5 = 0$. There were a few students who wrote down incorrect *t*-formulae for $\cos x$ such as $\cos x = \frac{1+t^2}{1-t^2}$ or $\cos x = \frac{2t}{1-t^2}$.

In part (b), most students correctly solved the equation $7t^2 - 5t - 5 = 0$ by using the quadratic formula. At this stage some students manipulated a correct $\tan\left(\frac{x}{2}\right) = \frac{5 \pm \sqrt{165}}{14}$ to give an incorrect $x = \arctan\left(\frac{5 \pm \sqrt{165}}{7}\right)$. Other students who achieved a correct $\frac{x}{2} = \{-29.26412..., 51.88499...\}$ then halved (rather than doubled) their results to give an incorrect $x = \{-14.6°, 25.9°\}$. It was pleasing that a significant number of students provided a fully correct solution to achieve both angles $x = -58.5°, 108.5°$ correct to one decimal place. Other common errors included failing to round their final answers to one decimal place; premature rounding earlier on in their working which led a loss of accuracy in their value(s) for *x*; rejecting negative values for *x* and additional solutions found in the range $-180° < x < 180°$. A few students substituted their values for *t* into both $\sin x = \frac{2t}{1+t^2}$ and $\cos x = \frac{1-t^2}{1+t^2}$. Some were successful, but this method gave additional solutions and these were rarely eliminated.

Question 2

This was a well-answered question with many students scoring full marks in part (a).

In part (a), most students applied two iterations of $\theta_{n+1} = \theta_n + h\left(\frac{\mathrm{d}\theta}{\mathrm{d}t}\right)_n$ for $n = 0, 1$ with $\theta_0 = 80$ and found their estimate for the temperature of the coffee 3 minutes after it was put in the room. The most common error was using an incorrect value for *h* such as 0.1, 0.15 or 1. Some students applied an incorrect $\theta_0 = 60$.

In part (b), some students demonstrated a very good understanding of the model by suggesting that '*k* should be decreased to become a smaller positive value'. Many students suggested that 'the value of *k* would need to be decreased' which was allowed as an acceptable suggestion. Incorrect suggestions included 'increase the value of *k*', '*k* should become more negative' or '*k* should satisfy $-1 < k < 0$'.

Question 3

This question discriminated well between students of all abilities.

There were a variety of methods which were used to find the correct critical values $-\frac{3}{5}$, 3, -1, -3. Most students, who were generally more successful, rearranged the printed inequality $\frac{x}{x^2-2x-3} \leq \frac{1}{x+3}$ to give $\frac{x}{x^2-2x-3} - \frac{1}{x+3} \leq 0$ and combined their algebraic fractions to achieve $\frac{5x+3}{(x-3)(x+1)(x+3)} \leq 0$. Other students, who multiplied both sides of the printed inequality by $(x-3)^2(x+1)^2(x+3)^2$ usually made a number of algebraic and manipulation errors, although some manipulated the result to give a correct $(x-3)(x+1)(x+3)(5x+3) \leq 0$. In both of these methods, a significant number of students made a bracketing error by manipulating a correct factor $(x(x+3)-(x-3)(x+1))$ to give an incorrect $(x+3)$ or an incorrect $(x-3)$. A few students, obtained a correct quartic inequality $5x^4 + 8x^3 - 42x^2 - 72x - 27 \leq 0$ followed by a correct $(x-3)(x+1)(x+3)(5x+3) \leq 0$. Most students understood the method of finding critical values and usually identified the correct regions. Many students, who did not consider the validity of their answer at $x = 3, -1, -3$, wrote down an incorrect answer $-3 \leq x \leq -1 \cup -\frac{3}{5} \leq x \leq 3$. Only a minority of students completed the problem by writing down a correct $-3 < x < -1 \cup -\frac{3}{5} \leq x < 3$.

Question 4

This question was accessible to most students, but it was clear that there were a few students who had not revised the vector cross product formula.

Most students arrived at the given answer in part (a) by applying the method $\frac{1}{2}\left|\overrightarrow{AB}\times\overrightarrow{AC}\right|$. Some students found the correct answer by applying the vector cross product between two other edges of triangle *ABC*. A few students arrived at the given answer by applying the formula $\frac{1}{2}\left|\overrightarrow{AB}\right|\left|\overrightarrow{AC}\right|\sin(B\hat{A}C)$, where angle $B\hat{A}C$ had been found by using the scalar product formula.

In part (b), many students applied the correct method $\frac{1}{6}\left|\overrightarrow{AD}\bullet\left(\overrightarrow{AB}\times\overrightarrow{AC}\right)\right|$ to find the volume of the crystal. There were several manipulation and calculation errors seen in evaluating the volume with some students evaluating $\overrightarrow{AB}\times\overrightarrow{AC}$ to give an incorrect $74\mathbf{i}-26\mathbf{j}+69\mathbf{k}$. Some students, who obtained a correct $\frac{1}{6}\left|\begin{pmatrix}-10\\-2\\-5\end{pmatrix}\bullet\begin{pmatrix}74\\26\\69\end{pmatrix}\right|$, evaluated this incorrectly to give $\frac{1}{6}\sqrt{(-740)^2+(-52)^2+(-345)^2}$. Many students converted the units correctly to find the density, with a few students converting the lengths to centimetres before evaluating the volume. The formula for density was known by most students, but there were instances of density written as $\frac{\text{Volume}}{\text{Mass}}$, $(\text{Mass})(\text{Volume})$ or $(\text{Mass})+(\text{Volume})$.

Question 5

This question discriminated well across higher ability students with part (a) more successfully answered than part (b). There were a significant minority of students who made no attempt or no creditable attempt at this question. It was clear that some of these students had not revised this area of the specification.

Some students were familiar with what was required in part (a). Students used a variety of methods to find $\frac{\mathrm{d}y}{\mathrm{d}x}$ with the most common being to make *y* the subject in order to find $\frac{\mathrm{d}y}{\mathrm{d}x}=-\frac{c^2}{x^2}$. Other students used implicit differentiation or the chain rule with parametric equations. Some students used the coordinates of *P* to obtain an expression for $\frac{\mathrm{d}y}{\mathrm{d}x}$ in terms of *p*, which was followed by a correct method for finding the gradient of the normal in terms of *p*. Many students who progressed this far usually applied a correct straight-line method and achieved the given equation $p^3x-py+c(1-p^4)=0$. A few students who did not use a calculus method to find $\frac{\mathrm{d}y}{\mathrm{d}x}=-\frac{1}{p^2}$ lost marks in part (a).

Part (b) proved to be more challenging for many students, although a few students produced fully correct and sometimes elegant solutions. A significant number of students made some progress by correctly substituting $y = \frac{c^2}{x}$ or $x = \frac{c^2}{y}$ into the given normal equation. Many students proceeded to form a 3-term quadratic equation, with some students at this stage unable to make any further progress. Of those who attempted to solve the quadratic equation, most used the quadratic formula. In many cases the algebra became cumbersome and many made algebraic errors which resulted in their being unable to find either the x or y coordinate of Q. Those who found the coordinates for Q usually produced a correct method for finding the coordinates of the midpoint of PQ.

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