Principal Examiner Feedback

Summer 2018

Pearson Edexcel GCE Mathematics

Core Mathematics C3 (6665/01)

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Introduction

The paper was found to be accessible to most students. There were ample routine tasks giving access to less able students while there were a few challenging parts to stretch even the best. Timing did not appear to be an issue on the people with the majority of students offering complete answer to all questions.

Applying rules such as the product and quotient rule for differentiation, or applying the rules of logarithms, was very well approached, with the majority of students taking the most direct routes. The algebraic manipulation was of a good standard, although dealing with the ln and exponential terms in question 3(c) stretched some.

The proof questions were generally answered well, but they did highlight the inability of some students to fully understand how to show each step of their working. Some were careless with presentation in these questions and lost marks, in particular, to incorrect notation.

Questions 1 (b) and 5(a) proved particularly discriminating, and the last two marks in question 6(b)(ii) were hard to score. Domains and ranges continue to confound many students, with the last mark of question 2 being gained infrequently, and the application of the $R\sin(\theta-\alpha)$ identity in question 9 was also a challenging part of this paper.

Students often missed keywords such as “hence” or “state” thus leading to unnecessary work. There was often a lack of attention to detail in ensuring the correct notation was used when working towards a given answer, including the correct use of brackets.

Presentation of work was generally clear, but there are still many students for whom a more structured approach to working would greatly benefit the legibility of the answers, especially when multiple attempts are made. It is important that students make their chosen final response clear and cross out unwanted work.

An increasing reliance on the use of calculators is becoming apparent. It should be noted that many questions required evidence of the method, as is made clear on the front of the examination paper, and students should be warned that answers without substantiating working may not receive credit.

Comments on individual questions

Question 1

A seemingly straightforward question was particularly discriminating where students lost marks due to weaknesses understanding, manipulating and solving inequalities.

In part (a), the product and chain rules were used successfully by the vast majority of students, many of whom found factorising the resulting expression to be more problematic than using calculus. Of those who did succeed in recognising and pulling out a common factor, many lost the final mark due to a factor of 2 remaining in their linear term. Rather strangely, the unsimplified answer of $2(3x-1)^4(3x-1+15x)$ was a common sight. Though rarely seen, some students did not recognise the need for the chain rule and treated the '2x' as a constant, using just the chain rule to differentiate $2x(3x-1)^5 \to 30x(3x-1)^4$.

Students scoring both marks in part (b) were few. Whilst many found the critical values, x = 1/3 and x = 1/18, most seemed unclear about how to proceed and merely opted to write down $1/18 \leq x \leq 1/3$. Others did not take account the fact that the question involved a non-strict inequality with the $(3x-1)^4$ term largely dismissed as being 'always positive' and so dy/dx = 0 was not solved.

Question 2

It was felt that the difficulty of this question was appropriate for its position in the paper with most of the marks easily accessible.

In part (a) the majority of students recognised the need to factorise the quadratic denominator, using the difference of two squares. From that point it was a fairly straightforward task of combining the three separate fractions with a common denominator of $(2x+5)(2x-5)$. Students who did not score all of the marks in (a) using this method usually did so due to algebraic slips or poor bracketing. Very few students resorted to combining all three denominators.

In part (b), students who either achieved the correct answer in (a) or obtained a fraction of the correct given form, were nearly always able to rearrange the algebra to obtain the inverse function. Expressing the answer in terms of x was nearly always achieved, and only very rarely was the answer left in an unsimplified form. Only a small minority this year mistakenly took $f^{-1}(x)$ to mean the derivative of f(x) and fewer still took it to be the reciprocal.

Realising that the domain of the inverse function is the same set as the range of the original function seemed to be partially understood in that many students mentioned 8/3 in their answer. However only a very small minority were able to correctly state that $0 < x < 8/3$.

Question 3

In a question testing the manipulation of exponential and logarithmic expressions, students would be wise to write their steps clearly and show all their working. This was found to be a relatively straightforward problem, yet many students failed to gain full marks due to confusion arising from poor use of notation and a lack of precision when using logs.

Students demonstrated a good understanding of initial conditions and almost all answered part (a) correctly. Parts (b) and (c) required students to form and solve equations, the former of which was performed very well in both parts of the question. A significant number of students however, upon reaching $k = -\frac{1}{2}\ln\left(\frac{3}{4}\right)$ in (b) and $\mathrm{e}^{-kt} = \frac{9}{32}$ in (c), were unsure how to proceed.

Moving directly from $k = -\frac{1}{2}\ln\left(\frac{3}{4}\right)$ to the given answer cost students the final mark in (b). For full marks, examiners required a correct intermediate step, demonstrating an understanding of the effect of both the half and the minus sign on the 3/4.

Those students in part (c) who used '*k*' in their working rather than $-\ln\left(\frac{2}{\sqrt{3}}\right)$ were generally more successful. Common errors seen using $-\ln\left(\frac{2}{\sqrt{3}}\right)$ were

- $\mathrm{e}^{-\ln\left(\frac{2}{\sqrt{3}}\right)t} = \frac{9}{32} \Rightarrow -\frac{2}{\sqrt{3}}t = \frac{9}{32}$ or similar
- $\mathrm{e}^{-\ln\left(\frac{2}{\sqrt{3}}\right)t} = \frac{9}{32} \Rightarrow \frac{\sqrt{3}}{2} \times \mathrm{e}^{t} = \frac{9}{32}$
- $\mathrm{e}^{\ln\left(\frac{2}{\sqrt{3}}\right)t} = \frac{9}{32} \Rightarrow \left(\frac{2}{\sqrt{3}}\right)^{t} = \frac{9}{32} \Rightarrow t = \log_{\frac{2}{\sqrt{3}}}\frac{9}{32} = -8.82$

Question 4

This question was well answered by the majority of students, with many students gaining full marks. In part (a), most students differentiated correctly and applied $x = 0$ to find the gradient of the tangent. Many then were able to find the equation for the normal. Marks were lost for numerous reasons such as

- differentiating $\mathrm{e}^{-2x} \rightarrow \mathrm{e}^{-2x}$ or e^{+2x}
- finding the equation of the tangent as opposed to the normal
- using the negative reciprocal of the expression for the gradient function itself, rather than its numeric value.

Part (b) was very well answered by students who had achieved part (a). Equating the curve to their straight line, then making x^2 the subject to arrive at the given answer, was generally well answered. Even if the equation was incorrect in (a), students managed to gain one mark.

It was very rare for students not to gain 2 marks in part (c), even by those who failed to achieve any marks on the rest of the question. Any errors seen were due to incorrect calculator work or misreads of their calculator display, eg 1.68… instead of 1.168. Students who did show working, before making a calculator error, could score one of the marks for a correct method.

Question 5

This question was answered with varying degrees of success dependent upon students' skills in understanding of the modulus function together with transformation geometry. It did prove to be a particularly discriminating question.

To be able to state the set of possible values of k in part (a), students had to envisage the graph of $y = k$ intersecting (or not) with f(x). More able students were able to do this, but as with question 1 many missed one of the solutions, namely, in this case, $k = 3$. Where this wasn't obvious to students, then more often than not, an algebraic approach was pursued. In most cases this was unsuccessful. While some students found either $k > 13$ or $k = 3$, very few found both solutions.

(b) This was the most successful part of the question with more students achieving the first solution of 6/5 (or 1.2) than the second solution of 34/3. Many students went on to achieve both x values with some wasting time and finding the coordinates of the intersections as well. Errors were still frequent where there was no real understanding of the modulus function or which part of the equation was affected by the modulus. Incorrect examples of this were:

- $2(5-x)+3=-\frac{1}{2}x+10$
- $-10-2x+3=\frac{1}{2}x+10$

Correct solutions were hard to achieve where students decide to square the modulus and / or the whole equation to achieve solution.

In part (c), students had to deduce/calculate that the vertex of f(x) had coordinates of (5, 3). They then had to interpret the $y = 4\text{f}(x - 1)$ as being the combination of two transformations: a translation in the x-direction of 1 unit followed by a stretch in the y-direction of scale factor 4. Common incorrect answers were $(20, 4)$ and $(4, 12)$ instead of the correct coordinates $(6, 12)$.

Question 6

In part (i), a significant majority of students correctly stated tan(2*x*+32) = 5 and then rearranged to get *x* = 23.35 achieving 3 marks out of 4. However, it was a very common error to work to an insufficient degree of accuracy when finding a second solution and state this as -66.66. A small minority of students chose to ignore the advice in the question and to rearrange the given equation to find a value of tan2*x*, and hence to find the two answers. Students who chose this method were not often as successful at getting at least 3 marks due to the greater likelihood of making an algebraic error when rearranging.

A majority of students scored both marks in (ii)(a). However, this was a proof and making no mention at all of the original LHS was a common cause of the accuracy mark being lost. Making sign errors in the use of the formula for $\tan(A-B)$ was only seen rarely.

In (ii)(b), a significant number of students were able to proceed to $\tan(\theta+28°)=\tan(3\theta-45°)$. It was at this point, however, where many problems started. It was expected that most could then easily deduce that $\theta+28°=3\theta-45°$ giving one of the solutions $\theta=36.5°$. Errors seen here were numerous including

- $\tan(\theta+28°)=\tan(3\theta-45°)\Rightarrow\tan\theta+\tan 28°=\tan 3\theta-\tan 45°$
- $\tan(\theta+28°)=\tan(3\theta-45°)\Rightarrow\dfrac{\tan(\theta+28°)}{\tan(3\theta-45°)}=1\Rightarrow\dfrac{(\theta+28°)}{(3\theta-45°)}=1$
- $\tan(\theta+28°)=\tan(3\theta-45°)\Rightarrow\tan(\theta+28°)-\tan(3\theta-45°)=0\Rightarrow(\theta+28°)-(3\theta-45°)=0$

Whilst many of these did lead to the correct answers, it must be pointed out that the marks cannot be awarded from incomplete or incorrect work

Question 7

This question which tested knowledge of the rules of differentiation as well as the ability to solve equations involving logarithms was tackled well by the majority of students. The vast majority of students used the quotient rule in (a). The latter required two applications of the chain rule and was therefore more prone to errors. Successful use of the chain rule when differentiating $\ln(x^2+1)$ was variable and the usual errors when applying the quotient rule were seen: the terms of the numerator the wrong way round, a plus used in the numerator or the denominator inadvertently not being squared. Students are advised to write the quotient rule formula down before substituting into it, in order to make their method clear.

In part (b) the first mark was scored by almost all students for setting their numerator = 0. Students who had made errors in part (a) then found it difficult to gain marks. Students who did do part (a) correctly, usually failed to gain full marks in (b) due to a lack of negative square root and the cancelling the '*x*' leading to a loss of the solutions (0, 0) and $\left(-\sqrt{\mathrm{e}-1},\dfrac{1}{\mathrm{e}}\right)$

Question 8

A score of zero was rare in part (a) of this question with many students scoring full marks. The quotient rule and the chain rule were used in roughly equal numbers. The main errors were:

- students losing the A1 mark due to incorrect/ inconsistent notation, usually dy/dx =…
- Failing to put in the required intermediate steps i.e. going straight from $\frac{\sin\theta}{\cos^2\theta} \to \sec\theta\tan\theta$

Many students also scored the first three marks in part (b). The differentiation was generally done well, and almost all could invert their d*x*/d*y* to d*y*/d*x*. Changing '*y*' to '*x*' when inverting was extremely rare.

However many students could not combine the identity $\tan^2 y + 1 = \sec^2 y$ with $\sec y = \ln x$. There was some unfamiliarity with squaring ln*x* to $\ln x^2$ instead of $(\ln x)^2$ and even this was quite often 'simplified' to 2ln*x*. Using $\ln^2 x$ was an acceptable alternative. Getting a correct dy/dx into the form required was also found demanding. Many just stopped at the form $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1}{x\ln x\sqrt{\ln^2 x - 1}}$ instead of the form demanded by the question. Some correctly found $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1}{x\sqrt{(\ln x)^4 - (\ln x)^2}}$ only to write $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1}{x\sqrt{4(\ln x) - 2(\ln x)}}$

Question 9

A significant majority of students gained all three marks in part (a). Of those who did not, the main error was due to using $\tan\alpha = \frac{1}{2}$ or -2, with just a few giving *R* as a decimal.

In (b)(i) many students stated a correct maximum value of 85, however a common mistake was to state it as 55 after not squaring the factor of 3. There were also some answers where $\sqrt{5}$ appeared in an expression. A very strange error of 40+45=95 was witnessed on numerous occasions.

Students who found the correct value of 85 in part (i) usually wrote down $\theta=2.68$ in part (ii). This was a follow through mark, so students who believed that $\alpha=0.464$ scored this for calculating $\frac{\pi}{2} + \alpha$

Only a small minority scored all three marks in part (c). In part (i) common incorrect answers were 30/15 = 2 , 30/7 or $30/(5\pm2\sqrt{5})$. The maximum value of $\mathrm{N}(\theta)$ is found when the denominator is minimised and hence when $\sqrt{5}\sin(2\theta - 1.107) = 0$

In (c)(i), the more able students found the correct answer of 6 but the correct value for the largest angle $\theta, 0 \le \theta \le 2\pi$ was found correctly by only by the most able. Common mistakes were to miss the fact that the angle had changed to 2θ rather than θ or to solve $2\theta - 1.107 = \pi/2$ or odd multiples of $\pi/2$, perhaps thinking that a maximum of a function involving sine has to happen when the sine is equal to 1

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