Examiners' Report
Principal Examiner Feedback

Summer 2017

Pearson Edexcel GCE Mathematics

Core Mathematics C3 (6665)

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Core Mathematics 3 (6665) – Principal Examiner's report

General introduction

The Core 3 paper was accessible to a wide range of students. Timing did not seem an issue as there were very few scripts where question 9 remained blank. Questions 1, 2, 3, 4a and 5 were familiar to students and provided a welcome source of marks. Question 6, 7, 8 and 9 were more discriminating but presented opportunities for the better students to show their skills.

Points raised from this examination that could be addressed by schools in future are:

- Students need to ensure that they have carefully noted the demand of the question. For example in question 2 and 3 exact solutions were required to score full marks. In question 7(i)(a) $\frac{dy}{dx}$ had to be written in a particular form.
- Solutions written straight down from a calculator were an issue. This was particularly evident in questions 4, 8 and 9. Students should be aware that the sentence "Solutions based entirely on graphical or numerical methods are not acceptable" means that intermediate steps need to be shown before marks can be awarded.
- The standard of some of the algebra seen, particularly on questions 3 and 7, was disappointing. See individual questions for comments.
- In questions on proof, e.g. 9(a), it would be a good idea for students to write out one coherent solution rather than leaving several unfinished attempts for the examiners to look through

Question 1

This was a familiar question on which to start. As a result it was done extremely well and students usually scored full marks. Students who did not score full marks, usually did so for not simplifying their answer. The most common mistakes noted during this question were:

- Unable to recognise the difference of two squares to factorise $x^2 - 9$
- Introducing a sign error when expanding the bracket $-2(x - 3)$
- Failing to realise that $2x + 6$ factorises and hence not cancelling $x + 3$ at the final stage

Question 2

This question was well answered question by students with most achieving high marks.

In part (a), almost all students scored the first two marks by correctly undoing the exponential equation to give $3x - 9 = \ln 8$ before proceeding to make x the subject. However, the question required the answer to be given in its simplest form and only a minority replaced ln8 by 3ln2 enabling their answer to be fully simplified. A few different approaches were seen, for example it was possible to proceed to a correct solution from either $e^{x-3} = 2$ (taking the cube root of both sides) or $e^{3x} = 8e^9$ (multiplying both sides by e^9)

Part (b) of this question was usually completed well with many students able to score full marks. The question required the students to apply the rules of logs to obtain an equation linking y and e before proceeding to make y the subject of the formula. Some sign errors were made when rearranging but these, on the whole, were rare. A costly error was where $\ln(2y+5) = 2 + \ln(4-y) \rightarrow 2y+5 = e^2 + 4 - y$

Question 3

Overall, this appeared to be a tricky question for students with many losing at least one mark, due mainly to inaccurate algebraic manipulation or numerical slips.

In part (a) the range was well identified with students stating either $g(x) \geq 3$ or $y \geq 3$. Incorrect answers were typically $g(x) \geq 2$, $x \geq 3$ or $g(x) > 3$.

In part (b), scoring 2 out of 3 marks was common due to an incorrect or missing domain, the latter being perhaps an indication of not reading the question carefully. The process of finding the inverse was well understood, although there was much more incorrect algebraic manipulation seen than expected. A surprisingly common error was to square each term or subtract 3 from each side and then square each term to obtain $x + 2 = y^2 + 9$. As well as having no domain given, common reasons for the loss of the final mark included a range of $x \geq -2$, $g^{-1}(x) \geq 3$ or $x \in$ R.

In part (c), most students attempted to solve $x = 3 + \sqrt{(x+2)}$. Poor algebraic manipulation and numerical errors were again in evidence and, again, some had difficulty squaring their expressions correctly. Surprisingly, some students could do (b) but not (c), and vice versa. Squaring each term individually limited students to 1 out of 4 marks, provided they correctly solved their resulting quadratic. Few gave a decimal answer or made errors using the quadratic formula but a substantial number of students failed to reject

$x = (7 - \sqrt{21})/2$ thus losing the final mark. The question asked for the value (not values) of x, and this might have been a clue for students to consider the domain of the function when giving their final answer.

In part (d) the mark was gained by students either giving the correct answer, or from following through on their answer to part (c). A number of students did not realise the connection with part (c) and tried to solve the equation algebraically, leading to a lot of work for only 1 mark. Many of the better answers included a diagram showing how the inverse was a reflection in the line $y = x$.

Question 4

Studentsew candidates used degrees or decimals to 2 dp contrary to the guidance in the question.

In part (b) the best solutions simply expressed the equation in terms of sin2*x* and cos2*x*, multiplied by sin2*x*, and finished with a straightforward rearrangement. Replacing cot2*x* by 1/(tan2*x*) didn't help unless converted to an expression in sin2*x* and cos2*x*. Writing the expression in terms of the single angles, sin *x* and cos *x* was unnecessary and usually unproductive.

Part (c) was simplified if candidates spotted the connection between the given equation and parts (a) and (b). Writing the given equation as $\sqrt{29}\cos\left(2x+0.381\right)=3$ was most likely to lead to at least one correct answer. A significant number ignored this link, but used double angle formulae to arrive at an equation involving sin*x* and cos*x*. Some developed this correctly into a quadratic in tan*x*, but most were unable make further progress. Candidates trying to "unpick" the trig statement were prone to losing a factor of 2 – effectively finding 2θ which they believed to be θ.

Question 5

For the vast majority of students, this question was very accessible with many producing fully correct solutions.

In part (a), students knew the method they should be using and usually proceeded to find an accurate equation of the normal. Nearly all calculated the correct y -coordinate of the point. Most students differentiated $2\ln\left(2x+5\right)$ to a correct form, but some failed to multiply by 2 giving $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{2}{2x+5}-\frac{3}{2}$. Others omitted to differentiate $\frac{3x}{2}$ whilst some attempted to differentiate it using the quotient rule. There were very few cases where the equation of the tangent was found instead of the normal. The majority of students successfully found the negative reciprocal of dy/d*x* at $x=-2$ and went on to substitute into a correct straight line formula. Students who substituted into $y=mx+c$ were usually able to find *c* and generate a correct equation. There were however, a significant number of students who lost the final accuracy mark for failing to write their equation in the required form $ax+by=c$.

In part (b), students were usually able to combine their linear equation with the equation of *C*. The most common approach was to make *y* the subject of their equation for the normal and then to equate with *C* before attempting to rearrange into the required form. The majority of students showed step by step working to reach their final answer which allowed them to gain method marks even if they were working with an incorrect normal equation.

Part (c) was completed well with most students scoring both marks. Most answers were given to the required accuracy and rounding errors were very rare.

Question 6

This question was answered to varied levels of success due to students' varied fluency with the modulus function.

In (a)(i), most students correctly sketched a V shape with the cusp on the *x*- axis. Marks were lost for failing to quote the correct points on the coordinate axes, most commonly $(a, 0)$ on the *x*-axis. In part (ii), most students translated their graph from part (i) up '*b*' units, and most were able to give the *y* intercept. A common mistake however, was to increase the *y* intercept by *b*, but to keep the minimum sitting on the *x*-axis rather than translating the entire graph vertically away from the *x*-axis.
Many students struggled with part (b). Spotting the link with part (a) and considering the intersection of each branch of the graph with $y = \frac{3}{2}x + 8$ would have guaranteed progress for many. There was however, widespread evidence that the different branches were not being considered and many attempted to keep the modulus whilst attempting to manipulate their equation(s). Often several different equations were formed with little structure and seemingly several activities going on at once, including removing the modulus signs both positively and negatively and using both resulting equations. As a result, it was common to see both $a + b = 8$ and $b - a = 8$ being used. As usual, the better answers used a sketch which clearly showed the two solutions and made it clear that $x = 0$ fitted the branch of the graph with a negative gradient and $x = c$, the branch with a positive gradient.

It was surprising to see how many students made numerical slips with minus signs in this question, or having correctly reached $c/2 = 2a$, failed to obtain $c = 4a$. A substantial number of students reached $c = 4/7a$ for correct work using the incorrect branches and they were able to gain 2 of the 4 marks.

Question 7

Students found this question to be quite challenging and it is noticeable that very few students managed to score full marks on this question.

In (i)(a), most students were able to differentiate but few were able to put this into the required form. A lack of confidence with algebra resulted in the loss of many marks in this question. Common errors witnessed in this part were

- Incorrect differentiation of $\left(x^2-1\right)^4 \to 4\left(x^2-1\right)^3$ within the product rule
- No use of the product with $2x\left(x^2-1\right)^5 \to 20x^2\left(x^2-1\right)^4$
- Use of an incorrect product rule $vu'-uv'$ or use of the quotient rule
- Incorrect simplification of terms such as $2x\times5\times2x\left(x^2-1\right)^4 \to 20x\left(x^2-1\right)^4$
- Incorrect stating of a $\mathrm{g}(x)$ from a correct derivative. For example, $2\left(x^2-1\right)^5+20x^2\left(x^2-1\right)^4=\mathrm{g}(x)\left(x^2-1\right)^4$ leading to an assumption that $\mathrm{g}(x)=2\left(x^2-1\right)^5+20x^2$ or $\mathrm{g}(x)=2+20x^2$

Part (i)(b) was also poorly attempted with many students only scoring M1A0. Where students managed to find the critical values they were not always able to find the correct solution to the inequality. Common mistakes were not knowing how to use the inequality signs or failing to recognise that $(x^2 - 1)^4$ was always positive and hence did not affect the inequality.

Part (ii) was also challenging. Many students attempted dx/dy but many 'lost' the 2 in 2 tan y. Almost all students then knew that to find dy/dx they needed to take the reciprocal of their dx/dy. Many students scored this mark but stopped there, not realising that they needed it as a function of x. Common errors witnessed by students who did continue were

- Failing to use the identity tan ^{2}(2y) + 1 = sec^2 (2y) with $\sec 2y=\mathrm{e}^x$
- Failing to simplify a correct $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{\mathrm{e}^x}{2\mathrm{e}^x\sqrt{\mathrm{e}^{2x}-1}}$ or incorrectly writing $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{1}{2\sqrt{\mathrm{e}^{x^2}-1}}$
- Using tan (2y) + 1 = sec (2y) to produce $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{1}{2\left(\mathrm{e}^x-1\right)}$
- Proceeding from a correct $\frac{\mathrm{d}x}{\mathrm{d}y}=2\tan 2y$ to an incorrect $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{1}{2\tan 2x}$

Question 8

The context of this question was familiar but the equation proved to be challenging to all but the most able, especially in part (c).

Part (a) was successfully answered by a correct substitution followed by an answer of 65. The answer of 25, being the most common wrong solution, which resulted from forgetting to add 40 in their calculation.

The differentiation in part (b) using the quotient rule was correctly carried out by many students. Those who stated the formula and the individual components of u, v, u' and v' were usually the most successful. A very small proportion attempted Product rule with limited success but, in both cases, students proceeded to make errors in simplifying (although full marks had already been awarded for the correct unsimplified answer). The most common errors were forgetting the denominator in the Quotient rule while others made slips on powers and/or signs.

The simplification of the differentiation from (b) proved too difficult for many students who scored no marks in this part. However, most recognised that for a maximum value they would need to equate their dP/dt to zero and attempted to find the value of t. Collecting together like terms and forming an equation was challenging with errors in manipulating negative indices and algebraic terms. Those students who proceeded to an equation with one exponential term usually managed to use logs effectively to find a value for t. A small number with the correct value for t failed to find a corresponding value of P, as required. It was noted that some students had clearly used a graphical calculator or the solve function which was stated in the question as unacceptable. Without sufficient working, students could therefore not achieve full marks for a correct answer.

In part (d), over half the students found the correct value of k, although there were many students who did not appreciate that they could answer this part independently of other parts and therefore did not attempt it.

Question 9

In Q09(a) the most common approach was that shown in the main scheme, starting with the left hand side of the identity and using $\sin 2x = 2\sin x\cos x$. Most students then went on to gain the next mark, writing $\tan x$ as $\sin x/\cos x$ and going on the express the two terms with a common denominator. There were many students who made no further progress, either stopping at this point, or going through several erroneous attempts to manipulate the expression before giving up. However, many students did proceed successfully, and some with elegant and concise solutions.

Those who began on the right hand side were generally more successful, particularly if $2\cos^2 x - 1$ was used as the initial identity. Again some very concise solutions were seen via this method, as well as cases which made little progress after the first step. Where little progress was made, they did not write $\tan x$ as $\sin x/\cos x$, or wrote $\cos 2x$ as $\cos^2 x - \sin^2 x$ and could not see how to proceed. Students should realise that if a printed result is being worked towards then it is essential that all the steps involved are shown.

For Q09(b) the majority of students attempted the method of the main scheme and eliminated the $\tan x$ to achieve an equation in $\cos 2x$ and $\sin x$. Attempts at the alternative method not using the identity from Q09(a) were not uncommon, but usually had less success. Most students were successful in obtaining the correct quadratic in $\sin x$. This could arise from either method, with either $\tan x$ or $\sin x$ being factored or cancelled out. Mistakes made in forming the equation often resulted from incorrect trigonometric identities, with $\cos 2x = 1 - \sin^2 x$ being a common error for the main scheme (leading to $\sin^2 x + 3\sin x - 1 = 0$), and incorrect multiplication through by $\cos x$ for the alternative. Solving the quadratic was generally soundly attempted, with only a small number of incorrect methods, such as attempting factorisation the correct quadratic (which does not factorise), or use of an incorrect quadratic formula. Those who solved the quadratic generally proceeded to find a value for x from their solution, and very many obtained the two correct answer 16.3° and 163.7°, though a few only obtained the first of these. The major problem in this part was in forgetting the solution $\tan x = 0$, which also gives rise to solutions. (In the alternative, omitting the $\sin x = 0$ through cancelling $\sin x$.) Students would do well to write their equation = 0 and factorise and consider each factor may be zero in order to avoid such errors. It is also noteworthy that students will regress to the use of graphical methods following incorrect work, where various incorrect equations have been formed from erroneous identities, but will then produce the correct answers. Students need to heed the warning that such approaches are not acceptable as they will not gain credit for such work.

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