Examiners' Report/
Principal Examiner Feedback

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GCE Core Mathematics C3 (6665) Paper 1

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General

Candidates generally found this paper accessible with attempts being made by almost all students on all questions. The standard of calculus and algebra was pleasing with question 1 and question 7 being a useful source of marks. Questions that proved to be more demanding were 3(b), 4(b) & (d), 5(c), 6(b) and 8(c). The length of the paper was not an issue as there was little evidence of students failing to finish. Points which need to be addressed by candidates in future examinations are;

- Candidates would be well advised to state formulae before using them
- Candidates should be more careful in their use/omission of brackets
- In 'show that' questions it must be stressed that all necessary steps must be shown
- The rubric clearly states that answers without working may not gain full marks. This was applied in 5(c), 6(bii),7(b) and 8(c).

Report on individual questions

Question 1

The majority of candidates knew the rules for differentiation and were able to apply them accurately.

Part (a) was generally well done with candidates scoring both marks. In those situations where candidates did not achieve the correct answer, $\frac{1}{x}$ or $\frac{1}{(2x+3)}$ or 1 over some other function of x was seen instead of $\frac{1}{(x^2+3x+5)}$ whilst others omitted the $(2x + 3)$.

In a minority of cases it was disappointing to see some candidates believing that $\ln(a + b) = \ln a + \ln b$ and applying this before attempting to differentiate. Surprisingly, many who failed in part (a) went on to succeed in part (b). The quotient rule was generally well known, but it should be noted that candidates should quote the formula before proceeding. Even though a version of the formula is given in the formula book some candidates still stated it incorrectly. Solutions were sometimes given without appropriate bracketing, multiplication signs (or dots), the presence of which make for better clarity and helps to avoid subsequent errors. The product rule, when attempted, was often correctly done, but on occasions the original expression was not adapted to $\cos x \times x^{-2}$ before differentiating.

Question 2

Part (b) was also more often than not fully correct. There was some evidence however of candidates who were not familiar with the arcsin function. As well as some who wrote "no arcsin button" there were other common errors which included

(i) evaluating $\sqrt{1-0.5x_n}$ and ignoring the arcsin,

(ii) $\text{arcsin}\sqrt{1-0.5x_n}$,

(iii) $\dfrac{1}{\sin(1-0.5x_n)}$ (with or without the square root),

(iv) $\sqrt{\sin(1-0.5x_n)}$,

(v) working in degrees.

Very few candidates failed to give the required accuracy, or rounded incorrectly.

In part (c) the majority chose the correct interval [0.801565, 0.801575] and completed the proof correctly. There were only a few incorrect intervals. Candidates who chose to proceed by repeated iteration were less successful. Most of them only worked to 5 decimal places and many did not proceed as far as x_7. Of the few who gave all the necessary results, there were not many who also gave a sufficient conclusion to complete the proof.

Question 3

This question tested the candidates' ability in transforming graphs. In part (a), the majority of candidates achieved all three marks. A few candidates applied only one of the two transformations resulting in R at (0, –3) or (4, –6). Others applied a scale factor of $\frac{1}{2}$ instead of 2 resulting in R at (0, –1.5). Both branches of the V were required to cross the x-axis and a few candidates lost a mark because of this. Wrong notation for (0, –6) was a little too frequently seen, but the position on the graph often clarified the students' intention.

Part (b) was more demanding. Candidates were generally conversant with the modulus function and sketched a 'W' shape. The most common mistake was to have the W shifted to the right so that at least one of the vertices was on the positive x-axis. Some candidates gave incorrect coordinates even though their drawing suggested that their R was correct. Even when the diagram was correct, R was at times seen labeled as (–3, 4), (3, –4) or (4, 3).

Question 4

A straightforward question testing understanding of log laws and functions. It was rare to get a fully correct answer, however the majority of candidates achieved at least half marks. It is obvious that many students struggle with the concepts of domain and range and how to find them.

In part (a) the vast majority of candidates had sensible ideas about finding the inverse of a function and the first method mark was usually awarded. The responses were approximately equally split on whether the variables x and y were interchanged at the beginning or at the end. They generally set their method out clearly thus gaining the second method mark. Some extremely poor algebra was seen however revealing a lack of understanding of the laws of logarithms.

Examples of this included going from $(4 - x)$ to $e^4 - e^x$. Sign errors were the biggest problem when taking exponentials, particularly for those candidates who tried to deal with $-\ln (x + 2)$, leading to $-(x + 2)$ rather than rearranging the equation to give $4 - y = \ln (x + 2)$. A few candidates managed to cope with $-\ln (x + 2)$ by converting it to $\ln (x + 2)^{-1}$ and then went on to gain full marks for this part.

Part (b) part caused more problems on the paper than any other part, with only the better candidates achieving the correct domain. There were a variety of numerical values given, but most just stated it as being any real number. When they managed to get 4, some wrote y or $f^{-1} \leq 4$ or $x > 4$, indicating that the idea of a domain was not fully understood. It was rare for students to spot the link between parts (b) and (d), so that if part (d) was correct, then part (b) was not modified.

In part (c) the composite function was well attempted and simplified. Very few applied the functions the wrong way around. Only a few failed to get the first mark by omitting +2 or -2. It was fairly common to see candidates getting to $4- \ln e^{x^2}$ and stopping, so not gaining any further marks.

Several opted to apply ln immediately without cancelling the 2s and got $+\ln 2 - \ln 2$. The candidates in part (d) were more successful here than in part (b), but there was little evidence of a realisation that the two answers were linked. A few graphs appeared, but it was surprising the number who correctly answered part (c) but could not establish the range of a negative quadratic. Again, stating the range was any real number or offering incorrect numerical values was common and also sometimes the wrong variable was used, for example x or $f(x)$.

Question 5

This question tested candidates on a 'real life' example of exponentials. Part (a) was very rarely incorrect. A few candidates did write p = 2.5 and then in (b) substituted 7.5 on the left-hand side. This seemed to be in an attempt to get straight to $\frac{1}{4}\ln 3$. A similar question to part (b) was asked in January and candidates had seemed to learn from that experience. Most seemed to score the first three marks. Some candidates still need to learn however that when an answer is given, it must be shown without doubt. For example justifying $\ln 3 = -\ln \frac{1}{3}$ proved difficult for many. It was not uncommon to see $k = -\frac{1}{4}\ln 3$ going straight on to $k = \frac{1}{4}\ln 3$ without any explanation.

Of those who did provide an adequate proof (a large minority), it was common to see $e^{-4k} = \frac{1}{3} \Rightarrow e^{4k} = 3$ used, and also $k = -\frac{1}{4}\ln 3 \Rightarrow k = \frac{1}{4}\ln\left(\frac{1}{3}\right)^{-1} \Rightarrow k = \frac{1}{4}\ln 3$.

Less common was $k = -\frac{1}{4}\ln\left(\frac{1}{3}\right) \Rightarrow k = k = -\frac{1}{4}(\ln 1 - \ln 3)$.

Part (c) was one of the more demanding parts of the paper; the derivative was not difficult but the numbers used made the question tricky. There were a pleasing number of completely correct solutions – by and large using the method shown on the mark scheme. A small number were able to proceed successfully with a change to powers of 3. The latter method did cause a lot of problems for most who attempted it; many had $3t^{-\frac{1}{4}}$ rather than the correct $3^{-\frac{1}{4}t}$. A common difficulty was processing the $-\frac{1}{4}(\ln 3)t$ and this was often caused by the lack of a bracket around the ln 3, so ln $3t$ was sometimes processed in error. Most candidates went on to give a numerical answer, but it was possible to achieve the final mark for a correct exact answer.

Question 6

This question was attempted by most candidates. The big difficulty here was in not using part (a) to help solve part (b). This is similar to what has happened in previous years and indicates that students are not aware that the question has been specifically designed to be solved in this way.

Most candidates coped well with the 'show that' in part (a). They were able to combine two fractions successfully and convert the expression from sin 2θ and cos 2θ into single angles, although the conversion of cos 2θ to a more appropriate form often required more than one stage of working. Those realising they should use $1 - 2\sin^2\theta$ for cos 2θ sometimes spoiled their proof by writing $1 - 1 - 2\sin^2\theta$ on the numerator thus reaching $-\frac{\sin\theta}{\cos\theta}$ and then conveniently 'losing' the – sign. Most of those reaching the final line gave sufficient evidence of method but a few left out crucial lines. It must be stressed that show that questions require all necessary steps.

Most candidates recognised the link between part (b)(i) and part (a) and used standard identities for sin 30° and cos 30°, subsequently providing a correct proof using $\frac{\sqrt{3}}{2} \times \frac{1}{2}$ or equivalents explicitly on an intermediate line, followed by simplification to $2-\sqrt{3}$. Note that $\frac{1}{\sin 30} - \frac{\cos 30}{\sin 30} = 2 - \sqrt{3}$ gained only 1 mark as the intermediate step was missing. Some candidates followed the alternative path offered by expanding $\tan(45-30)$ or $\tan(60-45)$. This group usually failed to rationalise the denominator in the surd fraction $\frac{3-\sqrt{3}}{3+\sqrt{3}}$, gaining 2 of the 3 marks. There were also some instances of $\frac{\sin 15}{\cos 15}$ being used, with surd values used from the calculator gaining no credit at all. Similar unacceptable methods used tan (30 – 15) or tan (75 – 60).

Part (b)(ii) was done very simply by good candidates who were able to write down tan $2x = 1$ and the 4 correct values within a couple of lines. However, many others failed to recognise that the given equation was similar to the original expression in part (a), inevitably returning to first principles with many attempting the Pythagorean identity "$\cot^2 x = \operatorname{cosec}^2 x - 1$", often with little or no success.

Question 7

The level of accuracy in part (a) was pleasing with a significant majority of candidates scoring full marks. Nearly all factorised $x^2 - 9$ correctly, although a few left the factorisation till further on in the question, making it more difficult. A few ended up with quartic functions but most of these candidates managed to reach the required result. Where there were errors, the main causes were the failure to include all necessary brackets leading to poor products, casual miswriting of signs part way through calculations and only occasionally showing an inability to deal with factors. A large proportion of candidates answered part (b) correctly and efficiently. Nearly all knew the required set of steps to reach the answer, with algebraic and arithmetical errors rather the cause of dropped marks. Other non-standard methods were seen, including splitting f(x) into partial fractions, writing f(x) as $5(2x + 1)^{-1}(x + 3)^{-1}$ then using the product rule and perhaps more elegantly writing the function as $\frac{5}{y}(2x + 1)(x + 3)$ and then differentiating implicitly. Those who multiplied out the brackets, followed by an application of the quotient or the chain rule differentiated most successfully. Errors arising from differentiating 5 to give 1, careless slips with the derivative of the denominator, missing brackets leading to to $-20x + 35$ were seen in equal measure.

Once the gradient had been found most candidates proceeded to find the equation of the normal without further problems. There was some evidence of numerical inaccuracy in substituting $x = -1$ into the gradient function, but nearly all candidates modified their tangent gradient to obtain the normal. One common error in calculating the gradient was a failure to square the denominator resulting in a value of $\frac{15}{2}$ which became $-\frac{2}{15}$ for the normal. Most candidates were able to find a normal gradient from a tangent gradient and use point P to form a straight line equation.

Question 8

Part (a) seemed well understood and there was a lot of correct work here. R was almost always found correctly, although there were some simple arithmetic errors where candidates had not use a calculator, for example $R^2 = 2^2 + 3^3$ leading to $R = \sqrt{10}$ or $\sqrt{15}$. There were more errors in the tan alpha part; the most common mistake was giving tan θ as $\frac{2}{3}$ or $-\frac{3}{2}$. A significant number used degrees here while others gave α in terms of π. Several candidates rounded their radian answer to 0.98, or 0.982.

In part (b) the differentiation was well done and most candidates achieved the first three marks. There were some sign mistakes and $\frac{d}{dx}(e^{2x}) = 2e^x$ also appeared. Only a few candidates omitted the 2 and the 3, possibly because they could see where they were heading. Most were then able to complete the proof, connecting their answer with part (a), although there was some unnecessary repetition of the working from part (a). As so often happens, with ‘show that’ questions, many lost marks by failing to show or missing out the factorising stage, candidates possibly unaware of the importance of it.

Quite surprisingly part (c) was found to be very demanding to all but the best of candidates. Many wrote $e^{2x} \cos (3x + \alpha) = 0$ but did not seem to realise that $e^{2x} = 0$ had no solution and hence went no further. Some confused “smallest x” with finding the minimum value so wrote
$\cos (3x + \alpha) = \pm 1$ followed by $3x + \alpha = \pi$ or 2π. Some put $3x + \alpha = 0$.

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