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Examiners' Report

January 2010

GCE

Core Mathematics C3 (6665)

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Introduction

This paper proved to be accessible to many of the candidature and there was little evidence of candidates being short of time. The paper afforded a typical E grade candidate plenty of opportunity to gain marks across the majority of questions. There was, however, more challenging material on the paper for the grade A*/A candidates.

The standard of algebra was generally acceptable, but some candidates showed weaknesses in using brackets and they were often omitted; this can lead to a loss of marks. For example, in Q9(ii)(b), $e^{2(\ln x - 1)} + 3$ cannot be accepted as equivalent to $e^{2\ln(x-1)} + 3$ unless the candidate "recovers" in their subsequent working. Also, in Q1, some candidates omitted the bracket around the subtracted term in the numerator of their combined fraction.

Some candidates gave incorrect answers to Q3(b) as a result of rounding their intermediate answers to too few significant figures or too few decimal places. A significant number of these candidates was usually penalised for giving an incorrect answer of 0.28^c, although fewer candidates also gave an incorrect answer of 4.92^c. In Q3, and also in Q7(c) there were a significant number of candidates who worked in degrees and converted their final answers to radians. Some candidates, however, worked completely in degrees. Examiners suggest that teachers should encourage some candidates to become more confident with working in radians.

In summary, Q2, Q3, Q6, Q7(b), Q9(i)(a) and Q9(ii) were a good source of marks for the average candidate, mainly testing standard ideas and techniques; and Q4(ii), Q5, Q7(a), Q7(c), Q8 and especially Q9(i)(b) were effective discriminators at the higher grades. A significant proportion of candidates, however, made little progress with finding the domain of $f^{-1}(x)$ and the range of $fg(x)$ in question 9(ii). Very few candidates incorrectly deduced that the equation $\cot 2x = 0$ had no solutions in the interval $0 \le x \le 180°$.

Report on individual questions

Question 1

This question seemed to cause a problem for a significant number of candidates, with some candidates making more than one attempt at the question. The most popular method was for candidates to combine the fractions and simplify their answer to give a numerator of $4x + 4$ and a denominator of $(3x^2 - 3)(3x + 1)$. Those candidates who progressed no further only gained the first 2 marks because of a failure to factorise $3x^2 - 3$. At this stage a significant proportion of these candidates factorised both $4x + 4$ and $(3x^2 - 3)$ correctly and proceeded to give the correct result.
The most concise correct solutions were achieved when the first term was simplified to $\frac{1}{3(x-1)}$ as this made manipulation simpler. Some candidates, who factorised $(3x^2 - 3)$ correctly did not always cancel out the common factor of $(x + 1)$, and so made the

combination of the two terms more complicated than necessary, often making careless errors as a result.
A significant proportion of candidates made a sign error usually by omitting a bracket around the subtracted term in their numerator. A few candidates incorrectly believed that $(3x + 1)$ could be factorised to give $3(x + 1)$.

Question 2

All three parts of this question were well answered by the overwhelming majority of candidates who demonstrated their confidence with the topic of iteration.

Part (a) was well answered by the majority of candidates although a significant minority of candidates were not rigorous enough in their proof. Some candidates assumed the step of factorising a common factor of x^2 from their first two terms rather than explicitly showing it. A few candidates attempted to reverse the proof and arrived at the correct equation but many of these candidates lost the final accuracy mark by not referring to $\mathrm{f}(x) = 0$.

Part (b) was almost universally answered correctly, although a few candidates incorrectly gave x_4 as 2.058.

The majority of candidates who attempted part (c) choose an appropriate interval for x and evaluated $\mathrm{f}(x)$ at both ends of that interval. The majority of these candidates chose the interval $\left(2.0565, 2.0575\right)$ although incorrect intervals, such as $\left(2.056, 2.058\right)$ were seen. There were a few candidates who chose the interval $\left(2.0565, 2.0574\right)$. This probably reflects a misunderstanding of the nature of rounding but a change of sign over this interval does establish the correct result and this was accepted for full marks. To gain the final mark, candidates are expected to give a reason that there is a sign change, and give a suitable conclusion such as that the root is 2.057 to 3 decimal places or $\alpha = 2.057$ or even QED.

A minority of candidates attempted part (c) by using a repeated iteration technique. Almost all of these candidates iterated as far as x_6 (or beyond) but most of these did not write down their answers to at least four decimal places. Of those candidates who did, very few of them managed to give a valid conclusion.

Question 3

This question was tackled with confidence by most candidates, many of whom gained at least 8 out of the 9 marks available.

In part (a), almost all candidates were able to obtain the correct value of R although $3^2 + 5^2 = 36$ was a common error for a few candidates, as was the use of the "subtraction" form of Pythagoras. A minority of candidates used their value of α to find R. Some candidates incorrectly wrote $\tan\alpha$ as either $\frac{5}{3}, -\frac{3}{5}$ or $-\frac{5}{3}$. In all of these cases, such candidates lost the final accuracy mark for this part. A significant number of candidates found α in degrees, although many of them converted their answer into radians.

Many candidates who were successful in part (a) were usually able to make progress with part (b) and used a correct method to find the first angle. A significant minority of candidates struggled to apply a correct method in order to find their second angle. These candidates usually applied an incorrect method of $(2\pi - \text{their } 0.27)$ or $(2\pi - \text{their } \alpha - \text{their } 0.27)$, rather than applying the correct method of $(2\pi - \text{their principal angle} - \text{their } \alpha)$. Premature rounding caused a significant number of candidates to lose at least 1 accuracy mark, notably with a solution of 0.28^c instead of 0.27^c.

Question 4

In part (i), the quotient rule was generally well applied in most candidates' working, although those candidates who decided to use the product rule in this part were usually successful in gaining all 4 marks.

A significant number of candidates struggled to differentiate $\ln(x^2+1)$ correctly. $\frac{1}{x^2+1}$, $\frac{2}{x^2+1}$ or even $\frac{1}{x}$ were common incorrect outcomes. In this part, candidates were not required to simplify their differentiated result and a significant number of them continued to simplify their answer further having gained all 4 marks. A significant number of these candidates appeared to struggle here owing to their weak algebraic and manipulative skills.

Candidates found part (ii) more demanding. Many candidates were able to write down $\frac{\mathrm{d}x}{\mathrm{d}y}$ correctly in terms of y and understood the process of taking the reciprocal to find $\frac{\mathrm{d}y}{\mathrm{d}x}$. Some candidates wrote $x = \tan y$ as $x = \frac{\sin y}{\cos y}$ and used the quotient rule to differentiate the result. At this point, some candidates did not make the link with the differentiated $\sec^2 y$ and $x = \tan y$ given in the question. Some candidates quoted the identity $\sec^2 y = 1 + \tan^2 y$ in the wrong variable and so it was not possible for them to complete the proof and score the final 2 marks in this part. There were a significant number of candidates who wrote $\frac{\mathrm{d}x}{\mathrm{d}y}$ as $\sec^2 x$, and so failed to score any marks for this part.

A large number of candidates, however, tried to make a link between part (i) and part (ii) of this question. These candidates either substituted $x = \tan y$ into their $\frac{\mathrm{d}y}{\mathrm{d}x}$ expression from part (i) or substituted $x = \tan y$ into $y = \frac{\ln(x^2+1)}{x}$. Some of these candidates then wasted time by unsuccessfully trying to prove the required result. It appeared that the more proficient candidates avoided this pitfall.

Question 5

Whilst most candidates knew how to draw $y = \ln x$, the graph of $y = \ln|x|$ was often misinterpreted as $y = |\ln x|$ or $y = |\ln|x||$ or $y = \ln(-x)$ and many other different combinations. Some candidates seemed to realise that the required sketch would be symmetrical about the y-axis even if they did not know the actual shape of the curve. A generous method mark in this question meant that few candidates scored 0 marks. Examiners also report that some candidates need to improve the presentation of their sketches.

Question 6

On the whole this question was well answered, with the majority of candidates achieving at least 7 of the 9 marks available. A significant minority of candidates, however, appeared to take little care when drawing their curves with a lack of precision in labelling and in the location of turning points. The size of some candidates' sketches caused some problems – the very large whole page graphs being quite difficult for candidates to sketch well and the very small graphs were hard for candidates to label and for examiners to decipher. Some candidates, in each part, by drawing more than one set of axes, showed their working in stages. Some candidates wrote transformed coordinates of $(2, 0)$ when they really meant $(0, 2)$.

Part (i) seemed to seemed to cause candidates more problems than the other two parts. Often a significant number of candidates reflected the original curve through the x-axis and translated the resulting graph up 1 unit to give a curve which went through the origin with a minimum turning point at $(2, -2)$. Other candidates only reflected the graph through the y-axis to give curve which cut the y-axis at $(0, 1)$ and had a minimum turning point at $(-2, 3)$.

Parts (ii) and (iii) were usually well done although the final mark in part (ii) was sometimes missed because of careless drawing of the maximum which appeared to be in the 1st quadrant, although labelled as being on the y axis. In part (iii), a common error was for some candidates to enlarge the original curve by a scale factor of 2.
While drawing the correct shape for (iii), with turning points in the correct quadrants, some candidates often made no attempt to indicate the stretch of scale factor $\frac{1}{2}$ parallel to the x-axis in their drawing. These candidates, however, did score full marks thanks to giving correct coordinates for the turning point as well as the y-intercept.

Question 7

In part (a), candidates used the quotient rule more often than a direct chain rule. The quotient rule was often spoiled by some candidates who wrote down that 1 was the derivative of 1. Another common error was for candidates to write down that $0 \times \cos x = \cos x$. Some proofs missed out steps and only fully convincing proofs gained all 3 marks with the final mark sometimes lost through lack of an explicit demonstration.

In part (b), many candidates differentiated e^{2x} correctly but common mistakes for the derivative of $\sec 3x$ were $\sec 3x \tan 3x$ or $3\sec x \tan x$. The product rule was applied correctly to $e^{2x} \sec 3x$ by a very high proportion of candidates, although occasionally some candidates applied the quotient rule to differentiate $\dfrac{e^{2x}}{\cos 3x}$. A few candidates applied the quotient rule to differentiate $e^{2x} \sec 3x$ when the product rule would have been correct.

Those candidates, who attempted to differentiate $e^{2x} \sec 3x$ in part (b), were able to set their $\dfrac{dy}{dx}$ equal to zero and factorise out at least e^{2x}, with a significant number of candidates getting as far as $\tan 3x = \pm k$, $(k \neq 0)$, with some candidates giving k as -2. Many of the candidates who achieved $k = -\frac{2}{3}$, were able to find the correct answer for a of -0.196, although a few of them incorrectly stated a as 0.196. A surprising number of good candidates, having found the correct value for x, were then unable to correctly evaluate y. It was not required to prove the nature of the turning point, so it was a waste of several candidates' time to find an expression for the second derivative.

Question 8

Weaker candidates struggled with this unstructured trigonometry problem and therefore it was common for examiners to see many unsuccessful attempts at this question. A significant number of candidates either did not remember or were not able to derive the identity $\operatorname{cosec}^2\theta = 1 + \cot^2\theta$. Some candidates could not use this identity to write down an identity for an angle of $2x$. Some candidates incorrectly deduced that $\operatorname{cosec}^2 2x = 2 + \cot^2 2x$.

A significant minority of candidates decided to work in sines and cosines, but only a few of these managed to get beyond the equation $1 - \sin 2x \cos 2x = \sin^2 2x$. Some of these candidates then proceeded to use double angle formulae resulting in an extraordinarily complicated equation involving $\sin 4x$, which they struggled to solve.

Those candidates who obtained a quadratic equation in $\cot 2x$ were usually able to solve it to obtain the two values for $\cot 2x$ as 0 or 1. Virtually all of these candidates, however, thought that it was impossible for $\cot 2x = 0$ to have any solutions. Those candidates who rewrote $\cot 2x = 0$ as $\dfrac{\cos 2x}{\sin 2x} = 0$ usually found both solutions of $x = 45^\circ$ and $x = 225^\circ$.

Question 9

A large majority of candidates were able to gain all 3 marks in (i)(a). The most common mistake was for candidates to make a slip when rearranging to give an answer of $\frac{1}{2}(e^5 - 7)$. A small minority of candidates, however, incorrectly manipulated $\ln(3x - 7) = 5$ to give either $\ln 3x - \ln 7 = 5$ or $3x - 7 = \ln 5$. A few candidates gave the decimal answer of $51.804...$, rather than the exact answer.

A significant number of good candidates struggled with (i)(b), thus making this question discriminating for capable candidates. The initial task of taking ln's was often done incorrectly with some candidates taking ln's but ignoring the 3^x term and other candidates replacing 3^x by 3. A significant number of candidates attempted to combine the indices to obtain the incorrect equation of $3e^{8x+2} = 15$. Another common error was for some candidates to write $\ln 3^x(7x+2) = \ln 15$. A number of candidates who wrote $7x + 2 = \ln\left(\dfrac{15}{3^x}\right)$, could not proceed any further. Some candidates often left solutions with x appearing on both sides and a small number who successfully gained the first three marks did not know how to proceed further. Candidates displayed total confusion at how to deal with the logarithm of a product and their general logarithmic manipulation was very poor. Many of them seemed completely lost as to how to approach the question, often attempting it several times. Having said this, examiners are pleased to report that a significant minority of candidates were able to obtain the correct answer with ease. Very few of these candidates were able to use elegant methods to arrive at the correct answer.

Part (ii)(a) was generally very well done with many candidates scoring at least 3 of the 4 marks available. Most candidates recognised the need for a "swapped y" method and were able to obtain a correct inverse function. The order of operations was not as well understood by a significant minority of candidates who usually found an inverse of $\frac{\ln x - \ln 3}{2}$. Although a significant minority of candidates were able to correctly state the domain, of those candidates who attempted to write down a domain, common incorrect responses included $x \geq 3$, $x \in \mathbb{R}$ or giving the domain in terms of y.

A majority of candidates found some success with finding the composite function $\mathrm{fg}(x)$ in part (ii)(b) and it was pleasing to see how many candidates understood the order of composition. Many candidates gained first 2 marks for initial form of $\mathrm{fg}(x)$ but struggled to simplify this, but they were not penalised by the mark scheme for doing so. A minority of candidates with poor bracketing lost the accuracy mark for $\mathrm{fg}(x)$. The range was as poorly answered with some candidates not appreciating the relevancy of the domain of $\mathrm{f}(x)$ in answering this question. There were a number of capable candidates who incorrectly stated the range of $\mathrm{fg}\,(x) \geq 3$.

Grade Boundaries

The table below gives the lowest raw marks for the award of the stated uniform marks (UMS).

Module	80	70	60	50	40
6663 Core Mathematics C1	63	54	46	38	30
6664 Core Mathematics C2	54	47	40	33	27
6665 Core Mathematics C3	59	52	45	39	33
6666 Core Mathematics C4	61	53	46	39	32
6667 Further Pure Mathematics FP1	64	56	49	42	35
6674 Further Pure Mathematics FP1 (legacy)	62	54	46	39	32
6675 Further Pure Mathematics FP2 (legacy)	52	46	40	35	30
6676 Further Pure Mathematics FP3 (legacy)	59	52	45	38	32
6677 Mechanics M1	61	53	45	38	31
6678 Mechanics M2	53	46	39	33	27
6679 Mechanics M3	57	51	45	40	35
6683 Statistics S1	65	58	51	45	39
6684 Statistics S2	65	57	50	43	36
6689 Decision Maths D1	67	61	55	49	44

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