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Examiners' Report/ Principal Examiner Feedback

Summer 2010

GCE

Core Mathematics C3 (6665)

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Introduction

This paper was found to be accessible by the candidates, and most appeared to show what they could do in terms of their skills. There was little evidence of candidates running out of time and the majority appeared to have enough time to do what they could on all the questions of the paper.

The standard of algebra was generally good, but some candidates showed weaknesses in using brackets which led to a loss of marks. Examples of poor bracketing were seen in Q4(b), Q5(c), Q5(d) and Q8(b).

In Q7 there were a significant number of candidates who worked in degrees and converted their final answers to radians. Some candidates, however, by working in degrees and not converting their degree answers to radians lost a considerable number of marks in part (c) and part (d). Again, as mentioned in January's Core 3 report, examiners suggest that teachers should encourage their learners to become more confident with working solely in radians when solving a trigonometric question which is posed in radians.

In summary, Q2, Q3, Q5(a), Q5(b), Q5(c), Q6(a), Q7(a), and Q8(a) were a good source of marks for the weaker candidate, mainly testing standard ideas and techniques; and Q4, Q6(b), Q6(c), Q6(d) and Q7 were effective discriminators at the higher grades. A surprising number of candidates used the quotient rule to differentiate $y = \dfrac{3}{(5-3x)^2}$ when the chain rule would have been more appropriate.

Report on individual questions

Question 1

This proved to be a fairly friendly opening question with about 45% of candidates gaining all 5 marks, with only about 10% of candidates unable to score.

In part (a), a majority of candidates were able to use both a correct identity for $\sin 2\theta$ as $2\sin\theta\cos\theta$ **and** a correct identity for $\cos 2\theta$ as $2\cos^2\theta - 1$ and were usually successful in their proof. There were a small minority of candidates who correctly replaced $1 + \cos 2\theta$ as $2\cos^2\theta$ and thus achieved the given result with ease. Those candidates who were less successful used correct identities for $\cos 2\theta$ as either $\cos^2\theta - \sin^2\theta$ or $1 - 2\sin^2\theta$ but failed to realise that they needed to apply the identity $\cos^2\theta + \sin^2\theta = 1$ in order to proceed to the correct result.

In part (b), a majority of candidates were able to make a link with part (a), to arrive at the equation $\tan\theta = \frac{1}{2}$, with many giving both correct angles of 26.6° and -153.4° in the range $-180^\circ \leq \theta < 180^\circ$. There were a significant minority of candidates who either only wrote down 26.6° or gave 206.6° as their second angle or gave extra solutions such as -26.6° or 153.4°. A significant number of candidates, surprisingly wrote down $\tan\theta = 1$, and proceeded in most cases to give 45° and -135°.

Question 2

This question provided candidates with many opportunities to score marks, with the method of differentiation to find an equation of the normal well known. About 47% of candidates gained all 7 marks and only about 15% of candidates scored 3 or fewer marks.

Use of the chain rule to find the gradient of the curve would have been the simplest method, but this was often not the choice made by the majority of candidates. When the chain rule was used, the result was often correct with only a few sign errors being seen. The expected error of $18(5 - 3x)^{-1}$ was only rarely seen. The quotient rule was commonly used, but unfortunately, some candidates made errors of differentiating $u = 3$ in the numerator to give 1 or differentiating $v = (5 - 3x)^2$ in the denominator to give $2(5 - 3x)^1$. A number of candidates multiplied out their denominator to give $v = 25 - 30x + 9x^2$ before being able to differentiate to find $\frac{dv}{dx}$. Usually the quotient rule was stated correctly, or at least applied correctly with the minus sign in the formula being evident, although some candidates wrote their terms in the wrong way round and some other candidates did not square v in the denominator to give $(5 - 3x)^4$.

Substituting $x = 2$ to find the y-coordinate and to find the gradient of the tangent were managed well, with only a few sign errors. A few candidates found the equation of the tangent and lost the final 3 marks. Also, a number of candidates failed to write the equation of the normal in the correct form and so lost the final accuracy mark. Having said this, most candidates were able to apply $\mathrm{m}(T).\mathrm{m}(N) = -1$ in order to find the equation of their normal.

Question 3

All four parts of this question were well answered by the overwhelming majority of candidates who demonstrated their confidence with the topic of iteration with around 65% of candidates gaining at least 8 of the 9 marks available.

Some candidates in parts (a), (c) and (d) worked in degrees even though it was stated in the question that x was measured in radians.

In part (a), the majority of candidates evaluated both $\mathrm{f}(1.2)$ and $\mathrm{f}(1.3)$, although a very small number choose instead to evaluate both $\mathrm{f}(1.15)$ and $\mathrm{f}(1.35)$. A few candidates failed to conclude "sign change, hence root" as minimal evidence for the accuracy mark.

Most candidates found the proof relatively straightforward in part (b). A small number of candidates lost the accuracy mark by failing to explicitly write $4\operatorname{cosec} x - 4x + 1$ as equal to 0 as part of their proof.

Part (c) was almost universally answered correctly, although a few candidates incorrectly gave x_1 as 1.3037 or x_3 as 1.2918.

The majority of candidates who attempted part (d) 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 $(1.2905, 1.2915)$ although incorrect intervals, such as $(1.290, 1.292)$ were seen. There were a few candidates who chose the interval $(1.2905, 1.2914)$. 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 1.291 to 3 decimal places or $\alpha = 1.291$ or even QED.

A minority of candidates who attempted part (d) by using a repeated iteration technique received no credit because the question required the candidate to consider a change of sign of $\mathrm{f}(x)$.

Question 4

This question discriminated well across all abilities with about 60% of candidates scoring at least 6 of the 10 marks available, but only about 10% of candidates scoring full marks. A significant proportion of candidates were able to offer fully correct solutions to parts (a), (b) and (c) but sometimes struggled to correctly state the range of g in part (d).

Part (a) was well answered and common errors included candidates incorrectly stating that the graph met the *x*-axis at $\frac{2}{5}$; or omitting the coordinates where the graph meets or cuts the coordinate axes; or drawing the graph of $y = |2x| - 5$. Candidates should refrain from using dotted lines and/or superimposing the graph of $y = |2x - 5|$ on top of the graph of $y = 2x - 5$. A separate labelled graph makes it easier for examiners to mark.

It was common for some candidates to find only one solution to part (b). The solution found from $2x - 5 = 15 + x$ was more often seen, but it was also very common to see just the solution from either $2x - 5 = -(15 + x)$ or $-2x + 5 = 15 + x$. Errors were seen in some scripts due to a lack of bracketing resulting in the equation $-2x - 5 = 15 + x$ being solved. A few candidates successfully achieved both answers by squaring the initial equation.

Part (c) was answered poorly by a significant number of candidates who found that $\text{fg}(2)$ was -11, with no evidence of the modulus having been applied. Also, a few other candidates who correctly achieved $|-11|$, believed that it was equal to ± 11. The expected error that candidates might find $\text{gf}(2)$ instead of $\text{fg}(2)$ was happily very rare.

In part (d), many candidates assumed that the boundaries for the domain would lead to the boundaries for the range and worked out $\text{g}(0)$ and $\text{g}(5)$ to give their range as $1 \leq g(x) \leq 6$. Fortunately for them this led to one of the marks being allocated for $\text{g}(5) = 6$. On the other hand, other candidates were able to work out the minimum of $\text{g}(x)$ by either using methods such as completing the square, differentiation or trial and error, resulting in $g(x) \geq -3$, but failed to spot the restricted domain so missing the maximum value of $\text{g}(5) = 6$. It is refreshing to see that more candidates are using the correct notation for the range, but examiners suggest that teachers need to continually remind candidates that the range should be expressed in terms of '$\text{g}(x)$'or 'y' and not in terms of 'x' . A significant minority of candidates, however, understood the restricted nature of $\text{g}(x)$ and were able to correctly state that $-3 \leq g(x) \leq 6$.

Question 5

This question was extremely well answered with 84% of candidates gaining at least 7 of the 12 marks available and about 42% gaining all 12 marks.

Nearly all candidates were successful in answering part (a). A few candidates were initially confused when attempting part (a) by believing that the curve met the y-axis when $y = 0$. These candidates quickly recovered and relabelled part (a) as their part (b) and then went onto to find in part (a) that when $x = 0,\ y = 2$. Therefore, for these candidates, part (b) was completed before part (a).

In part (b), some candidates chose to substitute $x = 2$ into $y = (2x^2 - 5x + 2)\mathrm{e}^{-x}$ in order to confirm that $y = 0$. The majority of candidates, however, set $y = 0$ and solved the resulting equation to give both $x = 2$ and $x = 0.5$. Only a few candidates wrote that $x = 0$ is a solution of $\mathrm{e}^{-x} = 0$.

In part (c), the product rule was applied correctly to $(2x^2 - 5x + 2)\mathrm{e}^{-x}$ by a very high proportion of candidates with some simplifying the result to give $(-2x^2 + 9x - 7)\mathrm{e}^{-x}$. Common errors included either e^{-x} being differentiated incorrectly to give e^{-x} or poor bracketing. The quotient rule was rarely seen, but when it was it was usually applied correctly.

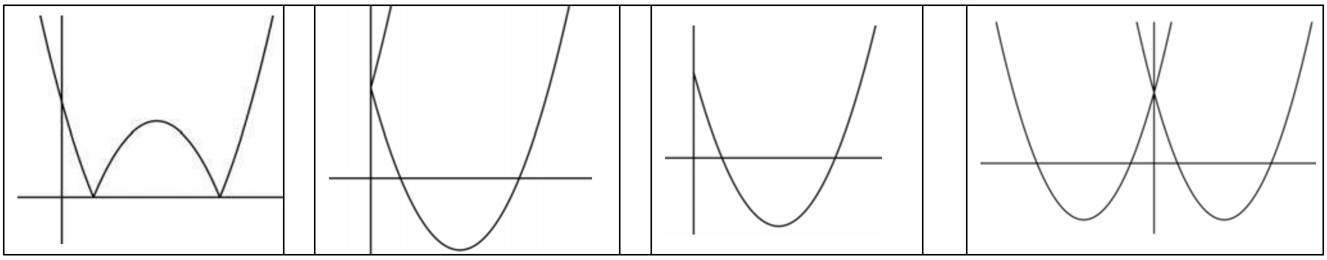
In part (d), the majority of candidates set their $\frac{\mathrm{d}y}{\mathrm{d}x}$ in part (c) equal to 0, although a few differentiated again and set $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = 0$. At this stage, few candidates produced invalid logarithmic work and lost a number of marks. Some other candidates made bracketing and/or algebraic errors in simplifying their gradient function. Most candidates realised that they needed to factorise out e^{-x} and solve the resulting quadratic with many of them correctly finding both sets of coordinates. Some candidates did not give their y-coordinates in terms of e, but instead wrote the decimal equivalent.

Question 6

This question discriminated well across all abilities with about 73% of candidates scoring at least 7 of the 10 marks available, but only about 13% of candidates scoring full marks. The majority of candidates were able to offer fully correct solutions to parts (a) and (b) but sometimes struggled to correctly answer parts (c) and (d).

In part (a), the majority of candidates gained at least 3 out of the 4 marks available. The most common errors were coordinates of $(-3, -4)$ stated in part (i) or $(1.5, -8)$ stated in part (ii).

The majority of candidates gave the correct sketch in part (b), although a few candidates incorrectly gave the coordinates of the turning points or omitted the value where $y = \mathrm{f}(|x|)$ meets the y-axis. The four most popular incorrect sketches are shown below.



Only a minority of candidates were able to correctly answer part (c). The most popular correct approach was for candidates to write down an equation for $\mathrm{f}(x)$ in the form $(x + p)^2 + q$ by looking at the sketch given in the question. Some candidates incorrectly wrote $\mathrm{f}(x)$ as $(x^2 - 3) - 4$, whilst others wrote $y = \mathrm{f}(x - 3) - 4$ but could not proceed to the correct answer. The method of writing $\mathrm{f}(0) = 5$ and $\mathrm{f}(3) = -4$, together with $\mathrm{f}(x) = x^2 + ax + b$ in order to find both a and b was successfully executed by only a few candidates.

In part (d), only a minority of candidates were able to explain why the function f did not have an inverse by making reference to the point that $\mathrm{f}(x)$ was not one-one or indeed that $\mathrm{f}(x)$ was many-one. In some explanations it was unclear to examiners about whether the candidates were referring to the function f or its inverse f^{-1}. The most common examples of incorrect reasons given were 'you cannot square root a negative number'; 'the inverse of f is the same as the original function'; 'it cannot be reflected in the line $y = x$'; ' f is a one-many function'; or 'a quadratic does not have an inverse'.

If a candidate made reference to a quadratic function they needed to elaborate further by referring to the domain by saying for example, 'In f, one y-coordinate has 2 corresponding x-coordinates'.

Question 7

This was the most demanding question on the paper and many candidates were unable to apply their successful work in parts (a) and (b) to the other two parts of the question. The mean mark for this question was 8.3 and about 12% of the candidates scored all 15 marks.

In part (a), almost all candidates were able to obtain the correct value of R, although a few omitted it at this stage and found it later on in the question. Some candidates incorrectly wrote $\tan\alpha$ as either $\frac{2}{1.5}, -\frac{2}{1.5}$ or $-\frac{1.5}{2}$. 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 the required radian answer.

In part (b), many candidates were able to state the maximum value. A significant number of candidates wrote down incorrect equations such as $2.5\sin(\theta - \alpha) = 1$ or $2.5\sin(\theta - \alpha) = 0$ in order to find θ. Few candidates attempted a calculus method and although some proceeded to achieve $\tan\theta = \pm k$, it was rare for them to find the correct answer of 2.21^c.

Many candidates failed to make a connection between part (c) and part (b). These candidates only worked with the given expression and assumed that the maximum occurred when $\sin\left(\frac{4\pi t}{25}\right) = 1$ and $\cos\left(\frac{4\pi t}{25}\right) = 0$. Of those who made the connection, many wrote down the correct maximum of 8.5 and solved $H = 8.5$ to achieve $\sin\left(\frac{4\pi t}{25} + \text{their } \alpha\right) = 1$ or made the link with part (b) to write $\frac{4\pi t}{25} = 2.214$. A significant number of candidates incorrectly solved $\frac{4\pi t}{25} = 2.214$ to give $t = 43.47$. Failure to correctly use a calculator correctly was apparent with dividing by 4π being processed by their calculator as "divide by 4 and multiply by π". Again, a calculus method was rarely seen and applied with little success.

Part (d) was a good source of some marks and was frequently well attempted by those candidates who had failed to make any headway with part (c). Again the "calculator error" lost candidates marks, with $t = 20.71...$ being seen on a number of occasions. Disappointingly, only a minority of candidates recognised the need for a second solution and so lost the final two marks. Some candidates did not appreciate that t was measured in hours and gave their answers as 2 minutes and 7 minutes past midday. Most candidates worked in radians, but those working in degrees usually tried to solve the equation $6 + 2.5\sin\left(\frac{4\pi t}{25} + 36.8699^\circ\right) = 7$ and so lost many marks.

Question 8

This question was well answered with candidates usually scoring either 3 marks (about 21%), or 5 marks (about 17%) or all 7 marks (about 46%).

The vast majority of candidates achieved all three marks in part (a). A significant minority of candidates used an alternative method of long division and were invariably successful in achieving the result of $2 + \dfrac{5}{(x-3)}$.

The laws of logarithms caused problems for weaker candidates in part (b). Common errors including some candidates simplifying $\ln(2x^2 + 9x - 5) - \ln(x^2 + 2x - 15)$ to $\dfrac{\ln(2x^2 + 9x - 5)}{\ln(x^2 + 2x - 15)}$ or other candidates manipulating the equation $\ln(2x^2 + 9x - 5) = 1 + \ln(x^2 + 2x - 15)$ into $2x^2 + 9x - 5 = e^1 + x^2 + 2x - 15$. Perhaps more disheartening was the number of candidates who were unable to make x the subject after correctly achieving $\dfrac{2x-1}{x-3} = e$, with some leaving a final answer of $x = \dfrac{1 + ex - 3e}{2}$. Those candidates who used long division in part (a) usually coped better with making x the subject in part (b).

Grade Boundary Statistics

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

Module		Grade	A*	A	B	C	D	E
		Uniform marks	90	80	70	60	50	40
AS	6663 Core Mathematics C1			59	52	45	38	31
AS	6664 Core Mathematics C2			62	54	46	38	30
AS	6667 Further Pure Mathematics FP1			62	55	48	41	34
AS	6677 Mechanics M1			61	53	45	37	29
AS	6683 Statistics S1			55	48	41	35	29
AS	6689 Decision Maths D1			61	55	49	43	38
A2	6665 Core Mathematics C3		68	62	55	48	41	34
A2	6666 Core Mathematics C4		67	60	52	44	37	30
A2	6668 Further Pure Mathematics FP2		67	60	53	46	39	33
A2	6669 Further Pure Mathematics FP3		68	62	55	48	41	34
A2	6678 Mechanics M2		68	61	54	47	40	34
A2	6679 Mechanics M3		69	63	56	50	44	38
A2	6680 Mechanics M4		67	60	52	44	36	29
A2	6681 Mechanics M5		60	52	44	37	30	23
A2	6684 Statistics S2		68	62	54	46	38	31
A2	6691 Statistics S3		68	62	53	44	36	28
A2	6686 Statistics S4		68	62	54	46	38	30
A2	6690 Decision Maths D2		68	61	52	44	36	28

Grade A*

Grade A* is awarded at A level, but not AS to candidates cashing in from this Summer.

- For candidates cashing in for GCE Mathematics (9371), grade A* will be awarded to candidates who obtain an A grade overall (480 UMS or more) *and* 180 UMS or more on the total of their C3 (6665) and C4 (6666) units.
- For candidates cashing in for GCE Further Mathematics (9372), grade A* will be awarded to candidates who obtain an A grade overall (480 UMS or more) *and* 270 UMS or more on the total of their best three A2 units.
- For candidates cashing in for GCE Pure Mathematics (9373), grade A* will be awarded to candidates who obtain an A grade overall (480 UMS or more) *and* 270 UMS or more on the total of their A2 units.
- For candidates cashing in for GCE Further Mathematics (Additional) (9374), grade A* will be awarded to candidates who obtain an A grade overall (480 UMS or more) *and* 270 UMS or more on the total of their best three A2 units.

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