Examiners' Report/
Principal Examiner Feedback

Summer 2013

GCE Core Mathematics C4 (6666)
Paper 01R

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Introduction

This paper proved to be accessible to many of the candidature and afforded a typical grade E candidate plenty of opportunity to gain some marks across all of the questions. At the other end of the scale, there were some testing questions involving binomial expansions, differentiation, integration and vectors that allowed the paper to discriminate well across the higher ability levels.

There was evidence of some candidates struggling to use and apply their Core 4 knowledge to a number of unstructured problems on the paper. For example, the majority of candidates in Q5(b) did not recognise that $\frac{2}{u(2u-1)}$ needed to be split up as partial fractions in order for it be integrated with respect to u. Also in Q7(b), the majority of candidates did not take stock and think about the implication of the tangent to the curve being parallel to the y-axis. Many candidates who had probably revised C4 by just looking at past papers simply answered this question in a similar way to how it has been answered before by setting $\frac{dy}{dx} = 0$. Therefore, examiners suggest that teachers may want to continue to develop their teaching and learning strategies to enable candidates to think more for themselves.

The standard of algebra was very good, although a number of candidates made basic sign or manipulation errors in Q1, Q2(b), Q4(b), Q7(b) and Q8(a). In summary, Q1, Q2(b), Q3, Q4(a), Q4(b), Q5(a), Q6(b), Q7(a) and Q8(a) were a good source of marks for the average candidate, mainly testing standard ideas and techniques; and questions Q2(a), Q4(c), Q5(b), Q6(a) and Q7(b) were discriminating at the higher grades. Q8(b) proved to be the most challenging question on the paper, with only about 10% of the candidature able to find both possible positions of B.

Report on individual questions

Question 1

This question was generally well answered with about 73% of candidates gaining at least 5 of the 7 marks available and about 44% of candidates gaining all 7 marks. Almost all candidates attempted this question with about 13% of them unable to gain any marks.

A significant minority of candidates performed integration by parts the wrong way round in part (a) to give $\frac{1}{3}x^3\mathrm{e}^x - \int \frac{1}{3}x^3\mathrm{e}^x \mathrm{d}x$ and proceeded by attempting to integrate $\frac{1}{3}x^3\mathrm{e}^x$. Some candidates failed to realise that integration by parts was required and wrote down answers such as $\frac{1}{3}x^3\mathrm{e}^x + c$. Few candidates integrated e^x to give $\mathrm{e}^{\frac{1}{2}x^2}$ or applied the product rule of differentiation to give $x^2\mathrm{e}^x + 2x\mathrm{e}^x$. The majority of candidates, however, were able to apply the first stage of integration by parts to give $x^2\mathrm{e}^x - \int 2x\mathrm{e}^x \mathrm{d}x$. Many candidates realised that they needed to apply integration by parts for a second time in order to find $\int 2x\mathrm{e}^x \mathrm{d}x$, or in some cases $\int x\mathrm{e}^x \mathrm{d}x$. Those that failed to realise that a second application of integrating by parts was required either integrated to give the final answer as a two term expression or just removed the integral sign. A significant number of candidates did not organise their solution effectively, and made a bracketing error which often led to a sign error leading to the final incorrect answer of $x^2\mathrm{e}^x - 2x\mathrm{e}^x - 2\mathrm{e}^x + c$.

In part (b), candidates with an incorrect sign in the final term of their integrated expression often proceeded to use the limits correctly to obtain an incorrect answer of $-3\mathrm{e} + 2$. Errors in part (b) included not substituting the limit of 0 correctly into their integrated expression; incorrectly dealing with double negatives; evaluating $2\mathrm{e}^0$ as 1 or failing to evaluate e^0. Most candidates who scored full marks in part (a), achieved the correct answer of $\mathrm{e} - 2$ in part (b).

Question 2

This question discriminated well across all abilities, with about 52% of candidates gaining at least 6 of the 9 marks available and about 20% of candidates gaining all 9 marks.

In part (a), the most popular method was to rewrite $\sqrt{\left(\frac{1+x}{1-x}\right)}$ as $(1+x)^{\frac{1}{2}}(1-x)^{-\frac{1}{2}}$ and achieve the result $1+x+\frac{1}{2}x^2$ by multiplying out the binomial expansion of $(1+x)^{\frac{1}{2}}$ with the binomial expansion of $(1-x)^{-\frac{1}{2}}$. Some candidates, however, were not able to formulate a strategy for expressing $\sqrt{\left(\frac{1+x}{1-x}\right)}$ in a form so that relevant binomial expansions could be applied. The most common mistake was to express $\sqrt{\left(\frac{1+x}{1-x}\right)}$ as $\frac{(1+x)^{\frac{1}{2}}}{(1-x)^{\frac{1}{2}}}$ and then try to divide the two expressions, once expanded, but without success.

Although many candidates had written $(1+x)^{\frac{1}{2}}(1-x)^{-\frac{1}{2}}$, a significant number did not attempt to multiply the two resulting expansions together, with several attempting to divide their expansions and some deciding to add their expansions after observing $\frac{1}{2}x$ both expansions. Many candidates were able to use a correct method for expanding a binomial expression of the form $(1+x)^n$ with some making sign errors when simplifying. The majority of candidates, however, who recognised the need to multiply the two expressions did so successfully, showing sufficient working and ignoring higher powers of x, to produce the given result.

Examples of alternative methods seen from a few candidates in part (a) included:

- $\sqrt{\left(\frac{1+x}{1-x}\right)} = \sqrt{\frac{(1+x)(1-x)}{(1+x)(1-x)}} = \sqrt{\frac{(1-x^2)}{(1-x)^2}} = (1-x^2)^{\frac{1}{2}}(1-x)^{-1}$, etc.

or

- $\sqrt{\left(\frac{1+x}{1-x}\right)} = \sqrt{\frac{(1+x)(1+x)}{(1-x)(1+x)}} = (1+x)(1-x^2)^{-\frac{1}{2}}$, etc.

In part (b), the main obstacle to success was the lack of realisation that a substitution of $x = \frac{1}{26}$ must be made into both sides of $\sqrt{\left(\frac{1+x}{1-x}\right)} = 1 + x + \frac{1}{2}x^2$. A significant number substituted into the RHS alone, assuming the LHS was $\sqrt{3}$ and claimed that $\sqrt{3} \approx \frac{1405}{1352}$. Even when candidates did substitute $x = \frac{1}{26}$ correctly into both sides, many neglected to equate both sides, and so had little chance of figuring out how to proceed to estimate $\sqrt{3}$. Those that equated both sides usually achieved the correct estimate of $\frac{7025}{4036}$.

Few candidates ignored the instruction given in part (b) and equated $\sqrt{\left(\frac{1+x}{1-x}\right)}$ to $\sqrt{3}$, deduced the value of $x = \frac{1}{2}$ and substituted this into the RHS in order to find an estimate for $\sqrt{3}$. Historically there have been a number of past examination questions that have asked candidates to "use a suitable value of *x*" and presumably these candidates had decided to do just that.

Question 3

This was a straight-forward question with about 55% of candidates gaining all 8 marks with an overwhelmingly majority of candidates realising that they needed to use radians in this question.

Although most candidates correctly computed 1.154701 in part (a), a significant number wrote 1.154700, suggesting that truncation rather than rounding was applied by some at this stage. Also an answer of 1.000004 was occasionally seen (a consequence of having the calculator in degrees mode).

In applying the trapezium rule in part (b), a small minority of candidates multiplied $\frac{1}{2}$ by $\frac{\pi}{8}$ instead of $\frac{1}{2}$ by $\frac{\pi}{6}$. Whilst the table of values clearly shows an interval width of $\frac{\pi}{6}$, the application of a formula $h = \frac{b-a}{n}$ with $n = 4$ instead of $n = 3$ sometimes caused this error. Other errors included the occasional bracketing mistake, use of the x-value of 0 rather than the ordinate of 1, and the occasional calculation error following a correctly written expression.

In part (c), the majority of candidates were able to apply volume formula $\pi\int y^2 \mathrm{d}x$, although a number of candidates used incorrect formulae such as $2\pi\int y^2 \mathrm{d}x$ or $\int y^2 \mathrm{d}x$ or even $\int y \,\mathrm{d}x$. Few candidates incorrectly wrote $\left(\sec\left(\frac{x}{2}\right)\right)^2$ as either $\sec\left(\frac{x^2}{4}\right)$ or $\sec^2\left(\frac{x^2}{4}\right)$. A minority of candidates integrated $\sec^2\left(\frac{x}{2}\right)$ incorrectly to give expressions such as $\frac{1}{2}\tan\left(\frac{x}{2}\right)$ or $\tan\left(\frac{x}{2}\right)$. The majority of candidates, however, were able to apply the limits correctly and recognised the need to give an exact final answer.

Question 4

This question discriminated well between candidates of all abilities, with about 59% of candidates gaining at least 6 of the 9 marks available and about 17% of candidates gaining all 9 marks. Part (a) was found to be accessible to most, part (b) less well answered and part (c) often either not attempted or incomplete.

In part (a), the majority of candidates were able to apply the process of parametric differentiation followed by substitution of $t = \frac{\pi}{6}$ into their $\frac{dy}{dx}$. Occasional sign errors were seen in the differentiation of both x and y and the 2 was not always treated correctly when differentiating $y = 1 - \cos 2t$ resulting in $\frac{dy}{dt} = \lambda \sin 2t \ (\lambda \neq 2)$. Other common mistakes included obtaining $t \pm 2\sin 2t$ or $2\sin t$ for $\frac{dy}{dt}$. A small number of candidates believed rewriting y as $2\sin^2 t$ made the differentiation of y easier. Most candidates showed the substitution of $t = \frac{\pi}{6}$ into their $\frac{dy}{dx}$ but many wrote down the numerical answer. Some candidates achieved $\frac{dy}{dx} = 1$ erroneously by either dividing $\frac{dx}{dt}$ by $\frac{dy}{dt}$ or from writing $\frac{dx}{dt} = -2\cos t$, $\frac{dy}{dt} = -2\sin 2t$. Few candidates formed the Cartesian equation (required in part (b)) and used this to correctly find $\frac{dy}{dx}$.

In part (b), sign errors, bracketing errors, manipulation errors, an inability to remember the double angle formulae for $\cos 2t$, and expanding $\left(\frac{x}{2}\right)^2$ to give $\frac{x^2}{4}$ were all common mistakes. The candidates who used $\cos 2t \equiv 1 - 2\sin^2 t$ were more successful in achieving $y = \frac{1}{2}x^2$ when compared to those who used either $\cos 2t \equiv 2\cos^2 t - 1$ or $\cos 2t \equiv \cos^2 t - \sin^2 t$. A small minority of candidates made t the subject in one of their parametric equations and found a correct alternative Cartesian form of $y = 1 - \cos\left(2\sin^{-1}\left(\frac{x}{2}\right)\right)$. Those candidates who attempted to find k usually found the correct answer of $k = 2$, although some incorrectly stated that $k = \frac{1}{2}$ or $k = \lambda\pi$.

Part (c) was not attempted by some and those that did often that gave partial or incorrect solutions such as $f(x) \geqslant 0$, $f(x) \leqslant 0$, $0 < y < 2$, $0 \leqslant x \leqslant 2$, $f(x) \leqslant 2$, $-2 \leqslant y \leqslant 2$, etc. A number of candidates also used incorrect notation for range.

Question 5

This question discriminated well between candidates of all abilities, with about 44% of candidates gaining at least 5 of the 10 marks available and about 28% of candidates gaining all 10 marks. Part (a) was found to be accessible, but most of the marks in part (b) depended on candidates identifying the correct strategy for integrating $\dfrac{2}{u(2u-1)}$ with respect to u.

Part (a) required candidates to 'show that', so it was expected that solutions would show clear steps to the printed answer given. Most candidates found either $\dfrac{dx}{du} = 2u$ or $\dfrac{du}{dx} = \dfrac{1}{2}x^{-\frac{1}{2}}$, although a few replaced dx with $\dfrac{du}{2u}$ instead of with $2u\,du$. In some cases dx was replaced erroneously by du or omitted throughout. The function of x was usually converted to a function of u correctly. There were some incorrect algebraic moves seen in attempting to reach the final answer especially in cases containing an error with dx. The final answer was sometimes written with the integral sign or du missing – thus not fully showing the answer required.

In part (b), only a minority realised that partial fractions were needed, often after attempting integration in several different ways. Once expressed in partial fractions, correct integration usually followed leading to a correct answer of $2\ln\left(\dfrac{5}{3}\right)$. Some candidates did make algebraic slips when forming their partial fractions or integrated $\dfrac{-4}{(2u-1)}$ incorrectly to give $-4\ln(2u-1)$.

Some candidates rewrote $\dfrac{2}{u(2u-1)}$ incorrectly as $\dfrac{2}{u} + \dfrac{2}{(2u-1)}$ or $2\left(\dfrac{1}{2u^2} - \dfrac{1}{u}\right)$. Other candidates wrote $\dfrac{2}{u} \times \dfrac{1}{(2u-1)}$ and integrated this to give $(2\ln u)\left(\dfrac{1}{2}\ln(2u-1)\right)$ or tried unsuccessfully to use a method of integration by parts. There were consequently many other incorrect versions of the integrated function which often, but not always, included a 'ln' term as suggested by the answer given in the question. Most candidates applied changed limits of 3 and 1 to their integrated function in u. Some candidates, however, converted back to a function in x and used limits of 9 and 1. Erroneous limits included 0 and 3 for u, and 1 and 81 for x.

Question 6

This question was generally well answered with about 57% of candidates gaining at least 8 of the 11 marks available and about 37% of candidates gaining all 7 marks. A minority of candidates made no creditable attempt in part (a) and then scored full marks in part (b).

In part (a), those candidates who were able to separate the variables, were usually able to integrate both sides correctly, although a number integrated $\frac{1}{120-\theta}$ incorrectly to give $\ln(120-\theta)$. Many candidates substituted $t=0, \theta=120$ immediately after integration, to find their constant of integration as $-\ln 100$ and most used a variety of correct methods to eliminate logarithms in order to achieve the printed result. A significant number of candidates, however, correctly rearranged their integrated expression into the form $120-\theta = A\mathrm{e}^{-\lambda t}$, before using $t=0, \theta=120$ to correctly find A. Common errors in this part included omitting the constant of integration, treating λ as a variable and incorrect manipulation in order to fudge the printed result. Also, a number of candidates struggled to remove logarithms correctly and gave an equation of the form $120-\theta = \mathrm{e}^{-\lambda t} + \mathrm{e}^{c}$ which was then sometimes manipulated to $120-\theta = A\mathrm{e}^{-\lambda t}$.

In part (b), most candidates were able to substitute the given values into the printed equation and achieve $t=161$ seconds. Some candidates made careless errors when manipulating their expressions, whilst a number did not round their answer of $160.94...$ to the nearest second. Few candidates substituted the given values into their incorrect answer from part (a).

Question 7

This question discriminated well between candidates of all abilities, with about 80% of candidates gaining at least 5 marks of the 12 marks available and about 45% gaining at least 8 marks. Only about 15% of candidates gained all 12 marks. Part (a) was answered well with full marks commonly awarded. Part (b) was far more challenging with only a small minority presenting a complete and correct solution.

In part (a), many candidates were able to differentiate correctly, factorise out $\frac{\mathrm{d}y}{\mathrm{d}x}$, and rearrange their equation to arrive at a correct expression for the gradient function. A minority did not apply the product rule correctly when differentiating $4xy$, whilst a small number left the constant term of 27 in their differentiated equation.

In part (b), those small proportion of candidates who realised they needed to set the denominator of their $\frac{\mathrm{d}y}{\mathrm{d}x}$ expression equal to zero usually went on to answer this part correctly. Some, however, did not attempt this part, while a majority attempted to solve $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$, and many proceeded to obtain coordinates of $(-6, 3)$ for the point Q, despite a number of them initially sketching a curve with a vertical tangent. A smaller proportion solved $\frac{\mathrm{d}y}{\mathrm{d}x} = 1$, presumably because the digit 1 is written as a vertical line; whilst others either substituted $y = 0$ or $x = 0$ into their $\frac{\mathrm{d}y}{\mathrm{d}x}$ expression. Manipulation and bracketing errors sometimes led to candidates writing equations such as $y^2 = A$ or $x^2 = A$, where A was negative. Examiners were surprised that a fair number of candidates, having obtained their value of x (or y), then proceeded to substitute this into $x^2 + 4xy + y^2 + 27 = 0$, rather than using the much simpler $y = kx$ or $x = ky$.

Question 8

In general, this was the most poorly answered question on the paper with about 25% of candidates failing to score. Some candidates did not seem to have a firm grasp of what was required and many produced pages of irrelevant working. This question did discriminate well between candidates of average to higher abilities, with about 54% of candidates gaining at least 4 of the 9 marks available and only about 10% of candidates gaining all 9 marks. Part (a) was found to be fairly accessible, and part (b) was challenging to all but the most able candidates. Many were unable to think about the question logically or produce a clear diagram and establish the relationship between the length of *AB* (and/or *PB*) and the length of *PA*.

In part (a), the vector $\overrightarrow{PA}$ (or $\overrightarrow{AP}$) was usually found, although sign slips, adding $\overrightarrow{OP}$ to $\overrightarrow{OA}$ and mixing up of the **i**, **j** and **k** components of $\overrightarrow{OP}$ were common errors. Many candidates found the correct value of *p* by applying the correct scalar product between $\overrightarrow{PA}$ (or $\overrightarrow{AP}$) and the direction vector $2\mathbf{i} + 2\mathbf{j} - \mathbf{k}$ and setting the result equal to 0, although some candidates used $\overrightarrow{OA}$, $2\mathbf{i} + 2\mathbf{j} + \mathbf{k}$ or $13\mathbf{i} + 8\mathbf{j} + \mathbf{k}$ instead of $2\mathbf{i} + 2\mathbf{j} - \mathbf{k}$. Other errors included taking the dot product between $\overrightarrow{OA}$ and $\overrightarrow{OB}$ or deducing $p = -1$ from a correct $4p - 4 = 0$.

Those candidates who attempted part (b) usually managed to find the magnitude of *PA* and many drew a diagram of triangle *PAB* correctly and deduced $PA = AB$. From this point, however, many candidates did not know how to proceed further, resulting in a lot of incorrect work which yielded no further marks. Some candidates, however, were able to form a correct equation in order to find both values of λ. It was unfortunate that a few, having found the correct values of $\lambda = -3$ and $\lambda = -7$ then substituted these into $\begin{pmatrix} 3 \\ -2 \\ 6 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 2 \\ -1 \end{pmatrix}$ instead of the equation for the line *l*. The most popular method for finding correct values of λ was for candidates to form and solve a Pythagorean equation in λ of $AB = 6$ or $AB^2 = 36$. Other successful methods for finding λ included solving $PB = 6\sqrt{2}$ or solving a dot product equation between either $\overrightarrow{PA}$ and $\overrightarrow{PB}$ or $\overrightarrow{AB}$ and $\overrightarrow{PB}$.

Few candidates realised that the length *AB* was twice the length of the direction vector of the line *l* and applied twice the direction vector $2\mathbf{i} + 2\mathbf{j} - \mathbf{k}$ in either direction from *A* in order to find both positions for *B*.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:
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