Examiners' Report
Principal Examiner Feedback

Summer 2017

Pearson Edexcel GCE Mathematics

Core Mathematics C2 (6664)

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Core Mathematics 2 (6664) – Principal Examiner's report

General introduction

The paper overall was found to be accessible to all students, though there were some discriminating places that challenged at the high end. Many of the Core Mathematics 2 topics were shown to be well understood, though logarithms still continue to cause difficulties for students. Variations on common themes, such as a leading negative term in the cubic in Question 6 or an area under the x-axis on Question 9, proved a good test of students' understanding of the topics.

There were many well crafted answers, with well explained responses to 'show that' questions. In contract there were also some poorly presented responses with difficult to read hand writing, making it hard to work out what the students were saying.
There were also a number of students who resorted to using calculator methods to solve questions without showing full working, which should be discouraged as questions are often requiring a particular method, indicated by a 'hence' or other similar instruction.

Question 1

This was an accessible question and a lucrative source of marks for the overwhelming majority of students. Those who retained the original expression and expanded binomially were generally the most successful; those who factorised out 3^5 occasionally made errors in the x terms, where brackets and powers were concerned.

The majority of students were aware that 'binomial coefficients' are required and the ${}^nC_r$ notation was the most commonly used and most attached them to the correct power of x, but a few missed a power out in the series. A few obtained their coefficients from Pascal's Triangle but many others used the expanded form of $n(n-1)/2$ etc.

Many students lost marks by missing negative signs in the second and fourth terms, while another common error was the bracketing mistake of forgetting to raise the $(-1/3)$ coefficient of x to the same power as x in the third and fourth terms.

There were only a small number of students who made the bracketing error ${}^nC_r$ $(3^r - (1/3\ x)^r)$ and hence obtained spurious extra constant terms which they then added to the 243.

There were some students who lost the final mark through carelessly expressing $10/3$ as 3.3 and omitting the recurring 'dot'.

Question 2

This was a well answered question with most students achieving at least some of the marks. The majority were able to draw the correct diagram then correctly state and apply the Sine Rule. However, a large proportion of students found only one angle, 70.5º, perhaps not having noted the request for ‘2 possible values’ or not knowing how to proceed or having forgotten the ambiguous case and the need to subtract from 180º. A significant number of those who did attempt to find a second angle incorrectly opted to find angle *BAC* rather than finding the second possibility for angle *BCA*. Of those students who correctly found 109.5º most stated and used ‘180-Ans’ or similar with a smaller number of students drawing the sine graph or unit circle to work out the second possibility using symmetry. A few added 70.5º to 90º and a few thought the second solution meant convert your answer to radians.

Occasionally students mislabelled the triangle and as a result needed to use the cosine rule in order to find the third side (12.6). Some students gave up at this point but others went on to use the sine rule and calculate an angle thus gaining 1 mark. Another reason for loss of marks was premature rounding used in the calculation of the angle θ in the triangle or in the result of sin θ. It is important to state any formula used in order to gain credit if there are errors in its application.

Very few students used radians, either correctly or using 50 radians. A few confused the sides and angles. The alternative method using the cosine rule and obtaining a quadratic equation in '*a*' was rarely seen and those who did use it usually failed to solve and obtain 14.6 and continue to find an angle.

Question 3

This was one of the easiest questions on the paper and many students were able to score full marks.

In Q03(a) the vast majority of students were able to correctly obtain $y = 6$ although there were a few who failed to achieve this value as a result of poor calculator skills.

Not surprisingly, many students scored well in part Q03(b) and most seemed very familiar with the trapezium rule. There was the usual confusion with ordinates and strips and a common error was to use $h = 2/5$, which is surprising given a table is given in the question paper. There seems to be an over reliance on the formula $h = (b - a)/n$ rather than interpreting the width from the table.

There were the usual bracketing errors, although many of these recovered to achieve full marks. A small number of students included an extra repeated term in their bracket, losing the method mark. A very small number attempted to integrate rather than use the trapezium rule.

Accuracy was good with the majority giving their final answer to 2 decimal places as instructed.

Q03(c) was attempted by most students with varying degrees of success. Many worked out that they were required to add on 10 by evaluating $\int_0^2 5 \, dx$, while a few were able to recognise the additional 10 without any working, realising that this was a translation of the given graph by 5 in the y direction, so the addition of a 5×2 rectangle was required. Another, often successful, method was to add 5 to all the initial values and apply the trapezium rule again, although this was susceptible to errors in calculation.

The most common error was to add 5 to the answer in part (b). Other students added 25 (from 5×5 added to the original table).

Question 4

This was a very well answered question with many students gaining full marks.

In parts Q04(a) and Q04(b) most students were correctly able to quote and use the formulae for arc length and sector area in radian form. A small minority converted the given angle from radians to degrees, before completing the required calculations, usually successfully.

A few students confused the two formulae, using an incorrect angle such as 1.77π, or incorrectly applying the formulae for radians after converting the angle to degrees. A small number of students assumed that the sketch was a semi-circle and treated AF, BF, DF and EF as radii of length 3.5.

In part Q04(c) many students used $\frac{1}{2}ab\sin C$ to find the area of the triangle and proceeded to add two of them to the area of their sector.

Although the area of the triangle was generally well attempted common errors included using a wrong side length, $A = \frac{1}{2}\times 3.5\times 3.5\times \sin\theta$ or omitting the sine, $A = \frac{1}{2}\times 3.5\times 3.7\times\theta$. There were also errors in finding the angle with some students using $2\pi - 1.77$ rather than $\pi - 1.77$ and also forgetting to divide by 2. A few students assumed the triangles were right-angled.

Students ought to be aware that the formula Area = $\frac{1}{2}ab\sin C$ is valid in radians, there is no need to convert the angle to degrees. Some found the angle and converted it to degrees unnecessarily leading to accuracy errors in the final answer. Many students used insufficient accuracy for the angle of their sector as 0.69 and gave the answer as 19.08 or incorrectly rounded their answer to 19.03, thus losing the final answer mark.

Using the height of the triangle $h = 3.5\sin(0.685)$ followed by Area = $\frac{1}{2}$ base × height was only used by a very small number of students, though they were often successful.

The majority of students earned at least the second M mark in Q04(c) for adding double their 'triangle' area to their 'sector' area, though a few used their arc length instead.

Question 5

This circle question was answered very well with many fully correct responses. Very few students used the equation of the circle in the form $x^2 + y^2 + 2gx + 2fy + c = 0$ to answer the question.

In Q05(a) most students were able to gain at least the method mark. Many did so by identification, recognising they needed half of the x and y coefficients in some way. Others attempted to complete the square on each term to obtain $(x \pm 5)^2 + (y \pm 3)^2 = \ldots$, though in some cases there was algebraic error in method (such as adding rather than subtracting the 25 and 9 from the terms). However they could still identify the correct centre (5,−3) from this, although some did still lose the accuracy mark as a result of sign errors. Answers of (−5,3) or (5,3) were common.

Part Q05(b) caused more problems and often led to incorrect answers, in particular, r=16 or r=4. These incorrect answers were sometimes stated following fully correct work as some students failed to remember the square of the radius is given in the circle equation. Another common error was poor manipulation of +30 which resulted in an incorrect answer for the radius of 8. Many students did not complete the square correctly, adding the square value instead of subtracting, and though they could gain both marks in Q05(a) from this, they could gain no marks here.

Part Q05(c) was well attempted by the majority of students. Substituting x=4 (even into an incorrect circle equation) enabled 2 of the 3 marks to be scored provided two solutions for y were found by correct method. It was also possible for students to score full marks here by using the given circle equation and this meant that full marks could still be scored here even when errors had been made in earlier parts.

Students often chose to unnecessarily expand the $(y+3)^2$ bracket and go on to use the quadratic formula, rather than simply square root both sides of the equation. This method saw more errors with sign changes resulting in the loss of the final accuracy mark. The quadratic formula was generally used correctly although the usual errors of using b instead of $-b$ were seen. The most efficient solutions moved from $(y+3)^2 = 3$ immediately to $y+3 = \pm\sqrt{3}$.

The geometric approach was rarely seen, but was usually successful when it was.

Question 6

Many students obtained full marks on this question, though a disappointing number lost the A mark in Q06(a) omitting a *conclusion*. There are also many students who do not distinguish between questions requiring factorization of a function and others asking for solution of an equation, dividing the function by the coefficient of the highest power or multiplying by (−1) and then not reversing that operation at the end.

In Q06(a) the vast majority used the factor theorem successfully; there were only very few instances of long division being used, which gained no marks in this part. A very small number substituted $x = 3$, not $x = -3$. It is worth reiterating that many students carelessly omitted to state that $(x+3)$ was a factor or give a suitable conclusion, resulting in a lost mark.

In Q06(b) most students used long division to obtain the desired quadratic, however there were often sign errors present in the final brackets or an incomplete factorisation. Most persevered with the original quadratic, but a many instead replaced this with a quadratic beginning with $6x^2$. Many of these students then forgot to adjust their brackets accordingly at the end, or to add a factor of (−1) to their factorization.

A significant number of students used the quadratic formula to obtain the roots of $-6x^2 + 11x + 7$, or equivalent, some of these going on to present the factors of $f(x)$ as $(x + 3)(x - 7/3)(x + 1/2)$, which does not show an acceptable attempt at the original cubic's factorization. Many others simply gave the roots.

The final answer to this part required a set of brackets with no common factors, hence the likes of $(x + 3)(3x - 7)(-2x - 1)$ were not acceptable, whereas $-6(x + 3)(x - 7/3)(x + 1/2)$ was. Students need to heed the 'completely' in the question and ensure any obvious numerical factors are accounted for.

For Q06(c), a smaller proportion gained full marks, though some of this was due to an incorrect answer to Q06(b). However, those that had either $(3x - 7)$ or $(7 - 3x)$ as a factor were able to access full marks and most completed a fully correct solution, though a few obtained $2^y = 3/7$. There were also many who correctly obtained $3\times2^y = 7$, but then proceeded to $6^y = 7$, demonstrating a fundamental misunderstanding of the rules for combining powers, and resulting in no marks for this part. There were also many students who thought the roots of the cubic equated to 2^y, 2^{2y} and 2^{3y}, equating them in order to their values of x – often ending up with 2^{2y} or $2^{3y} = 7/3$ instead.

Most were able to state that the negative values were invalid, though nearly as many simply referred to "Math Error", the result of trying to obtain the logarithm of a negative number on their calculator, and so again failing to show an appreciation for indices work. Also, a minority tried to find logs of negative numbers by ignoring the minus signs resulting in extra solutions that lost the final A mark.

A few students failed to see any connection between Q06(b) and Q6(c) and gained no marks here.

Question 7

Logarithms continue to be a topic that test even the best students, and this proved a testing question.

Q07(a) was the most challenging of the two parts overall with the most common score being M1M0A0.

Most students secured the first mark by applying the power law correctly, usually to the left-hand side. The majority of these students then went on to remove logs correctly, although sometimes by an indirect route involving collecting log terms on one side, using the subtraction law and then proceed from $\log(A/B) = 0$ to $A/B = 1$. It was the next step that proved the most difficult; many students expanded the brackets on the left-hand side to give a quadratic, but then were unable to solve their quadratic by a suitable method and instead made one of the x's the subject ending with an expression containing x on both sides. The students who realised they needed to square root both sides to give the much simpler "$x+a$ =..." had more success, but still made errors as they did not correctly deal with both the 16 and a^6.

Another common mistake seen when using the power law on the right-hand side was interpreting $\log(16a^6)$ as $\log(16a)^6$ when applying log rules.

Some students who used a valid method then lost the final A mark by neglecting to reject the negative square root, but the majority who worked correctly towards the final answer gave only the positive square root and gained full marks.

Q07(b) was done much better with full marks being the most common score. Students displayed a high level of competence in this type of log work, with the first of the two methods shown in the mark scheme being by far the most common approach.
Of those who did not gain full marks, the subtraction law was generally used correctly thus gaining at least the first mark. Only a few made the error of writing log(..)/log(..) instead of log(../..).

The second mark was also generally well attempted, though some students then struggled to remove logs correctly, a common error being cubing 2 as opposed to squaring 3. Errors from this point were usually slips in rearranging when making y the subject, or failing to make y the subject at all, either erroneously making b the subject, or leaving as $9y = 10b$, which lost them the final two marks. When a correct linear equation was reached and an attempt at making y the subject followed, the correct usually resulted, though a number of cases were seen where errors in rearrangement occurred even at this stage.

Question 8

This was another question that proved challenging with fewer full mark responses to this question than for any other question on the paper.

In Q08(a) the vast majority of students showed good familiarity with the Pythagorean trigonometric identity and very few did not secure the B mark. Indeed, most went on to rearrange their equation to a suitable form to gain the M mark. It was the final stage of completing the proof that caused students difficulties with many unable to communicate effectively. It was common for students to omit a suitable intermediate step between forming a 3 term quadratic and the final result so scored A0. Some students went to the other extreme and showed excessive working, suggesting they did not know what was considered sufficient.

The second method, Way 2 on the mark scheme, was seen occasionally, but students often omitted any conclusion and gained two of the three marks available. More common was to see students work from both ends towards quadratic before deducing their expressions were equivalent.

Q08(b) was done with varying degrees of success, but the mark patterns generated were very regular. A common response seen was a correct start by square rooting both sides of the equation; in this method, a common error was students forgetting the negative square root, thus only gaining a potential maximum of three marks. It was this error that good students commonly made to prevent full marks on the question.

Many also incurred errors when making sin x the subject, and $3\sin x - 1$ was often misinterpreted as $3\sin(x-1)$ or $3(\sin x - 1)$ meaning incorrect processing with the rearrangement so no further marks could be scored. Some thought they were solving $(3\sin x - 1)^2 = 0$ and gave $\sin x = 1/3$ as a solution.

Alternatively, many students expanded the brackets of the equation from part Q08(a) and attempted to solve it using the quadratic formula. This was often done correctly with less chance of losing the negative square root, but subsequent accuracy errors were all too often incurred. Those who used decimal answers for sin$x$ sometimes did not use enough figures to obtain the accuracy required. Some students also were unable to find the solutions arising from the principle value $x = -7.94°$, attempting $180° - 7.94°$ for example, or omitting them completely as $-7.94°$ is "out of range".

Question 9

This question proved to be a discriminating question producing marks across the full range from 0 to 12 with access for most students but challenging even good students in places.

Q09(a) provided students with the opportunity to demonstrate an understanding of the structure of geometric series. There were many very good coherent well set out answers. Nevertheless, many failed to even identify the given terms as a, ar and ar^2, labelling instead as u_1, u_2 and u_3 and often making no progress. Attempts at arithmetic sequence approaches were not uncommon, and also attempts at forming the sum of three terms were attempted (usually unsuccessfully, although some cases did succeed this route).
The students who did appreciate that $r = u_{n+1}/u_n$ usually went on to gain at least the first three marks, and there were many students who started directly with the equation $\frac{5k-7}{7k-5} = \frac{2k+10}{5k-7}$ or a variation of this, such as $(7k-5)\times\left(\frac{5k-7}{7k-5}\right) = 2k+10$. Alternative methods, such as using the sum of the first three terms, tended not to be as successful due to the more demanding nature of the algebraic manipulation required to form the correct three term quadratic equation in k.

Students should be reminded that in questions in which the answer is given to them in the form of a 'show that' then examiners are expecting to see sufficient working to prove that the result has been derived accurately (and not just stated after only a line or two of either correct or incorrect working).

A number of students made simple sign errors when manipulating their algebraic expressions or, after completing all required working accurately, failed to write down the required quadratic equation accurately either by missing off the equal zero or stating one of the coefficients or the constant term incorrectly.

That the equation for k was given on the paper gave access to Q09(b) and the majority of students did therefore gain at least one mark in this part. Incorrect attempts to solve the equation were rare.

Attempting to solve the equation was the most common route though many students opted only to verify that 9/11 was a solution of the given equation, and so gained only one mark. For those who did solve the equation, those using the formula generally stated both roots before making a selection, but those who chose to factorise did not always indicate in any way why the root from the other factor need not be considered. The assumption was that obtaining 9/11 was sufficient, without realising the need to demonstrate it could be nothing else, failing to pick up on the relevance of stating 'given that k is not an integer' in the question. Students could benefit from being advised to identify *how* the information is relevant in such a 'show that' question.

Q09(c) again provided challenges for students. Though many were able to successfully complete all parts, there were also many who were unable to identify r correctly, using k instead. Obtaining a value for a was more successful, though often this was implied in working or embedded in a formula rather than stated. A good methodology of identifying key information first before using it would benefit students.

Those who correctly stated both the values of a and r usually went on to correctly find the fourth term of the sequence. The most common method here was using the formula for the fourth term, but astute students were able to use the third term and their ratio to find the fourth term.

Common errors were either considering ar^4, assuming that the common ratio was equal to k or finding the ratio to be 4 or ¼. Bracketing errors also occurred, but in this case the answer ended up negative anyway, so it was not possible to tell if they had been included or not.

Finding the sum of the first 10 terms was less successfully attempted. Though many students correctly found the sum of the first 10 terms there were also many who did not deal accurately with the negative value of the common ratio in the formula. Here is a place where students would be well advised to quote a formula before using it as a very common error here was to try and write out an expression for the sum directly, but lose marks due to bracketing errors. The answer $\frac{\left(\frac{8}{11}\right)\left(1+4^{10}\right)}{1+4} = 152520.2909$ was common, and with no quoted formula gained no marks as the correct method is not implied. However, quoting the formula first meant the method could be awarded.

Question 10

In Q10(a) the majority of students scored full marks by differentiating and then attempting to solve $\frac{dy}{dx}=0$, often simplifying the quadratic before solving it. The most common errors involved losing the last mark for either an incorrect factorisation or for stating an incorrect root of $\frac{dy}{dx}=0$, usually $\frac{5}{2}$, $\frac{2}{5}$ or $-\frac{2}{5}$. The majority of students who substituted $x = 1$ into $\frac{dy}{dx}$ to demonstrate that $\frac{dy}{dx}=0$ did not gain the final mark as they did not write a conclusion that this meant that the point was a turning point.

In Q10(b) only a minority of students scored full marks, with the majority struggling to identify the correct limits and combination of areas required. Although there were a few students who made no attempt to find y when $x = 1$, the majority found $y = -25$ or the equation of the line $y = 25x - 50$ and gained the first B mark. Several also found the correct area of the triangle and gained the second B mark.

The majority of students were able to integrate, usually correctly and gain the first M1 A1 marks. The most common errors when integrating were to make a slip on one of the terms or to differentiate instead. It was more common to see the limits of 2 and $-\frac{1}{4}$ used rather than 1 and $-\frac{1}{4}$. Those who used 1 and $-\frac{1}{4}$ were usually able to get the correct answer and gain full marks. Some calculation errors were made in the substitution of $-\frac{1}{4}$ into the integrated function and many students made errors with subtracting negative results.

A common error was to find the area under the whole curve and then subtract the area of the triangle. Some students attempted to find the unshaded area by using limits of 2 and 1 and then subtracting the triangle area and a minority of these students managed to obtain a fully correct solution using this method.

For those who subtracted their line equation from the curve equation, most gained the M1A1 marks for correct integration of their cubic but again it was common to see 2 and $-\frac{1}{4}$ used as limits earning none of the last 3 marks. Students using this method were more likely to make an error even when the method was sound, due to the increased number of steps required.

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