Examiners' Report

Principal Examiner Feedback

Summer 2017

Pearson Edexcel International A-Level in

Core Mathematics C34 (WMA02/01)

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General introduction

Students found this paper accessible although it was not clear whether the number of blank responses to some of the later questions was indicative of students running out of time. The quality of many responses seen was high, showing that students had been well prepared by their teachers. Q5(c), Q10(c), Q12, Q13, and Q14 were found to be the most challenging on the paper. Overall the level of algebra was pleasing, although a lack of bracketing was apparent in some cases, particularly 13(b). Some students are clearly relying heavily on their use of calculators, as correct answers, for example to definite integrals, appear too often with no working. A point that could be addressed in future exams is the lack of explanation given by some students in making their methods clear. Students need to be aware that when asked to produce, or prove, a given result they must be careful to include all the necessary steps, and to check that they have not made a slip in presenting the final result.

Report on Individual Questions:

Question 1

There was a mixed response to this question. There were some very good answers where students worked confidently through each stage arriving at the correct answer. The majority were able to implicitly differentiate the equation correctly. The most common error was failing to use the product rule for the $2xy$ term. A few were unable to deal with the $4y$ term correctly and left out the $\mathrm{d}y/\mathrm{d}x$ and a few forgot to differentiate the + 4 term. Some students started immediately with "$\mathrm{d}y/\mathrm{d}x =$" in front of the differentiated equation but then dropped it rather than including it as an extra $\mathrm{d}y/\mathrm{d}x$ term. Errors often appeared in collecting terms and rearranging rather than in the differentiation. Almost all students substituted the given x and y values to find the gradient at the relevant point although a few only did so after they had inserted it into the equation of a line. Some students found a normal instead of a tangent and slightly more failed to give the equation in the required form with integer coefficients.

Question 2

For most students, this was a straightforward question and they were frequently able to achieve full marks. Some errors were seen in the application of integration by parts with some students trying to integrate the wrong way round, setting u as $x – 2$ and $\mathrm{d}v/\mathrm{d}x$ as $\ln x$ with no further progress being made. A fairly common error was to see the x^2 on the denominator being treated as if it was written on the numerator. These students were still able to obtain method marks later in the question. There were few responses where students omitted to substitute the given limits and it was also not uncommon to see the limits only substituted into the expression obtained from second integration. Errors in basic integration were also seen, reducing the power by one instead of increasing and forgetting to divide by the new power, were the most common errors and integrating x^{-2} as $\ln x^2$ was also seen. There were also a few responses where answers were not fully simplified. For example, $–1/e – 1/e$ was not collected to give $–2/e$.

Question 3

(a) Most found one end of the range correctly (usually $y > 0$) but not many found both. The correct notation was seen for the most part. Very occasionally "f " was used instead of "g", and "x" was used to express the range by a very few. The use of "x" for the range gained no marks unless both ends of the range were correct. Those who got the answer fully correct tended to sketch the graph.

(b) The majority of students scored at least 2 out of 3 in (b). Almost all understood the process to find an inverse function and obtained a correct expression for the inverse. Sign errors were rarely seen. In a few responses students showed they did not understand the notation and they found the derivative of g instead of its inverse. Many used their answer to (a) giving the domain in terms of x, knowing that the range of g was the same as the domain of its inverse, and gained the B1ft mark, often when no marks were gained in (a). A popular incorrect answer for the domain was $x \neq 3$. However, a considerable number of students omitted an attempt at the domain of the inverse function.

(c) Most students wrote down a correct expression for gg(x), showing an understanding of composite functions. A few miscopied g(x) and used $6/(2x + 3)$. Good algebraic skills were seen mostly but many failed to simplify the expression fully to the required answer of $4x/(2x + 1)$, the most common example being $36x/(18x + 9)$. However a considerable number of students were not able to simplify the denominator of $2(6x/(2x + 3)) + 3$ correctly, sometimes cancelling the $(2x + 3)$ without dealing first with the + 3 but in general being unable to deal with an algebraic fraction correctly.

Question 4

(a) The majority of students scored full marks and very few failed to get any marks at all. Almost all got the first B mark for using a power of –2 and most also took out a factor of 3^{-2}, but some struggled to deal with multiplying this back into their final expansion. A significant minority of students incorrectly thought the factor was 3 or 1/3. The alternative method of using the binomial expansion $(a + b)^n$ without taking out the factor of 3 was rarely seen. Most students applied the binomial expansion formula well with many able to get a method mark for correctly expanding their $(1 + kx)^{-2}$ with the structure for at least 2 correct terms. Marks lost were usually on numerical slips such as failing to expand $(–5/3x)^3$ correctly. A few had difficulties working with fractions and some students did a restart for part (b) and quite a few restarted for part (c). They were often successful though it would use up more of their time. Students who correctly calculated the 1/9 multiplier sometimes forgot to use it in their calculations in (b) and (c).

(b) The vast majority saw the connection with part (a). The most common error was changing the sign in only one term or in 3 or all 4 terms. But most students coped with changing the signs of appropriate coefficients and so they gained this mark even if they had gone wrong in (a).

c) Students found this more difficult than (b). Quite a few expanded the expression again but often did not use $k = –1/3$, whilst those who realised the connection often just divided every term by 5 instead of the relevant powers of 5. Those who started again from the beginning tended to be more successful.

Question 5

(a) There were as many attempting to form the required identity by multiplying by the denominator $(2 - x)(1 + 2x)$ to find A, B and C, as used algebraic division to find A followed by using the linear remainder to find B and C. The first method was usually more successful for finding B and C. Most used substitution of values rather than equating coefficients to find B and C. Marks lost using substitution were often when replacing x by $-1/2$ and making a sign error. Those using algebraic division often found an incorrect remainder resulting from arithmetic slips. A few divided the denominator by the numerator. Occasionally the numerator and denominator had a factor of -1 taken out and then the resulting remainder was put over the old divisor resulting in the signs of B and C being wrong. A minority failed to appreciate the question was relating to an improper fraction and either decided $A = 0$ or simply ignored A and set up an incorrect identity in just B and C, which, while leading to the correct B and C values, gained no marks. Another minority attempted division "the wrong way around", obtaining a quotient of 3 from the 2 in the expanded denominator and the 6 in the numerator, leading to a quadratic remainder all quite correctly, but then set $A = 3$ incorrectly and equated this quadratic remainder to a linear expression having multiplied through, again leading to correct B and C values but no marks were scored because of an incorrect method.

(b) Most differentiations obtained powers of (-2) and used the chain rule on $(1 + 2x)$, but many missed multiplying the $(2 - x)$ term by (-1). There were a significant number of students who incorrectly differentiated to get $\ln(2 - x)$ and $\ln(1 + 2x)$ terms. A minority used the quotient rule on each fraction but this was often done correctly. Attempts to use the quotient rule on the original function were seen occasionally but generally were not very successful. Some attempted to find the inverse function.

(c) This was very poorly answered, with many students leaving this part of the question blank. Those who attempted it either just stated that the gradient was negative, or used some numerical values of x to justify the decreasing function rather than notice that both terms would be negative due to the denominators being squares and the numerators both negative.

Question 6

Many students were successful in finding whether or not the lines intersected. Rather less succeeded in showing that the lines were not parallel. Students did not need to have knowledge of the word "skew" although many of them were aware of its meaning.
Showing "not parallel": Most of the students who attempted to show the lines were not parallel did so by writing out the direction vectors and stating that they were not equal. Identifying the direction vectors was essential for this mark. Other students attempted to use the scalar products of the direction vectors and should have shown that $\mathbf{d1} . \mathbf{d2} \neq |\mathbf{d1}||\mathbf{d2}|$. However, many of them showed that the lines were not perpendicular instead. Some who used the scalar product and worked out the angle between the lines to be 41.5° unfortunately failed to state that this implied the lines were not parallel. Students who looked at the ratio of the corresponding components were usually successful.
Showing "not intersecting": This was done well by many students. The most commonly seen solution was to simultaneously solve the equations from the **i** and **j** components obtaining $\mu = 9$ and $\lambda = 16/3$. There were very few slips in working. Then, to substitute these values of μ and λ into their corresponding **k** components, showing that these values were different. Most who had done this then correctly stated that the lines did not intersect. Students also used **i** and **k** components initially or **j** and **k** components were also successful. Those students who did not succeed on this part had tended to use two equations to find μ and λ, but then substituted these values back into one of the equations that they had just used instead of the remaining one.

Question 7

(a) Most students made a good attempt and realised that they had to use a double angle identity to end up with an expression of the form $\sin 2x/\cos 2x$. The most common way was to use $\cos 2x = 1 - 2\sin^2 x$ in the numerator and $\cos 2x = 2\cos^2 x - 1$ in the denominator. However, this was a "proof" and so students were required to show all steps in their working. A significant number of students omitted the step showing $2\sin 2x/2\cos 2x$. Some students combined the use of a double angle substitution along with $\sin^2 x + \cos^2 x = 1$. A small number of students made incorrect substitutions or errors with signs. A small number of students began with $\tan 2x$. As this was a proof, all steps needed to be shown including the cancelling the factors of ½.
(b) Students who successfully made the substitution of $2\tan^2\theta$ for the expression $2(1 - \cos 2\theta/1 + \cos 2\theta)$ often scored full marks in this part. The majority of successful students formed a three term quadratic equation in $\sec\theta$ but those who formed a three term quadratic in $\cos\theta$ were equally successful. If a three term quadratic was formed, these were generally well solved and mostly by factorisation. A few of these students did lose the final accuracy mark for failing to identify the second solution for θ in the range. There was a significant number of students who failed to see the connection between the parts and they struggled to secure any marks in part (b). There was a small number of students who incorrectly tried to use $\sec^2\theta + 1 = \tan^2\theta$ and some who obtained $\tan\theta + 1 = \sec\theta$ after incorrectly taking square roots. It was rare to see students forming a quadratic equation in $\tan^2\theta$ and many who tried this method were unsuccessful.

Question 8

a) This question was well answered. Errors for the approximation were usually a result of using the wrong value for the strip width, commonly 5/6. Sometimes the final A mark was lost for what appeared to be careless use of a calculator. This A mark was also lost through rounding errors (2.376, 2.37, 2.378, 2.4...). A few neglected to put brackets around 0.5(0.6325 + 0.3742) + 2(0.5477 + 0.4851 + 0.4385 + 0.4027) which cost them the M mark unless they showed that they had used brackets invisibly by having the correct answer subsequently.

(b) Marks were quite polarised in this part, full marks or 0. Some students did not know how to find the volume of revolution and so did not square the expression for y and this caused great difficulty when they tried to integrate the expression. Even those who squared y often had problems integrating. It was common to see $x\ln x$ or $x^2\ln x$ for the integration. Some students unsuccessfully attempted integration by parts. Many did not recognise that the numerator was the derivative of the denominator and even when they did, they did not always know that the integral was a logarithm and made flawed attempts at long division. Those that correctly integrated using logs often gained full marks. There were some instances of $\ln x^2 + 1$ without brackets which caused difficulties later. A few worked in decimals so losing the final A mark. Some successfully used a substitution however, those who took this approach sometimes failed to change the limits. A few forgot that π is necessary for the volume, forgetting either to write it in at the beginning or to carry it through in their working, thus losing the final A mark and some students lost the final mark for not simplifying their answer.

Question 9

(a) Most students were successful at using the dot product identity $\mathbf{a}\cdot\mathbf{b}=|\mathbf{a}||\mathbf{b}|\cos\theta$ to find the angle, although a few either generated a sign error in their working or simply decided that the dot product had to be positive, often putting a modulus sign around the scalar product, which resulted in the angle 72.06 rather than the correct answer 107.94. The magnitudes of the vectors were usually found accurately using Pythagoras. Occasionally students arrived at the correct angle but then went on to subtract it from 180, clearly under the impression that the angle had to be acute, and therefore lost the final A mark. A minority attempted to use the cosine rule to find this angle, although making arithmetical mistakes when finding the length of BC prevented some from achieving the correct answer. A few students rounded before using arccos which led to an angle that was not sufficiently accurate and lost the A mark. Very few students worked in radians.

(b) The vast majority of students applied 1/2 $|\mathbf{a}||\mathbf{b}|\sin\theta$ correctly and were awarded both marks, even when using the 72.06 answer from part (a). Some students used $\cos\theta$ within the formula and so lost both marks. Most errors were rounding errors or by using an incorrect angle from part (a).

(c) This part of the question was answered correctly by significantly fewer students than parts (a) and (b). When trying to find the length *BC*, students sometimes made arithmetical mistakes when calculating the components, which still allowed the method mark, but some added vectors AB and AC to form vector BC. From finding length *BC* most students correctly used the area of *ABC* from (b) along with *BC* to find the perpendicular length *A* to *BC* that was required.

A common error was simply to divide the angle *BAC* by 2 and attempt to use trigonometry in a right-angled triangle to find the height of the triangle.

A number of students did not use their answer to part (b), but rather used the sine rule to find one of the other two angles in triangle *ABC* and then applied various trigonometrical methods to the right-angled triangles formed by the perpendicular from *A* to *BC*. Although a longer method, this did show some competence in trigonometry and did obtain the correct answer on occasion. There were cases where students used a formula for triangle area without "½" in it.

Question 10

(a) This part was generally answered correctly, being a standard piece of theory which students seemed to know well. The value of $\alpha = -26.6$ was seen occasionally, as was 63.4 resulting from $\tan\theta = 2$. Also, the value of α was sometimes found first and then used to find *R*, resulting in an inexact value and a lost mark. It appeared that some students had learnt a particular way of expressing $a\sin\theta + b\cos\theta$ and used a learnt formula which did not apply to $R(\sin\theta - \alpha)$.

(b) The first mark for the correct shape of sketch was mostly well answered. A few sketches failed to show the second maximum and instead stopped, continued up, or were asymptotic. Cusps rather than rounded minimums were seen in virtually all responses, and the *y*-intercept was often seen as the same height as the maximum value of *y*, this being acceptable for the mark. A few students decided to make their sketch on the given sketch which led to B0 as it was not possible to decide which part of the combined sketch the student wished to be considered.
A significant number of students failed to give the intercepts with the axes for the 2nd and 3rd marks, presumably simply overlooking that they were required for two further marks. Full marks were the exception among those who presented answers; a *y*-intercept of $\sqrt{5}$ was quite common, while some used $y = \sqrt{5}(\sin(-26.6)$ and gave 1.001. $(0, -1)$ was seen very rarely, but highlights the necessity of students checking that answers are sensible given that this was positioned on the positive *y*-axis. For the *x*-intercepts several students subtracted their alpha from 180 instead of adding it and lost this mark. There were a variety of other answers all of which showed a degree of confusion with the demand here.

(c) A number of students missed this part completely and appeared confused over the demand and applied the result from part (a) to " 5 + 2sin(15t) - cos(15t)".
Where answers were presented, (i) which asked for the maximum value of the expression was usually answered well, although a number gave the answer as "5 + 1" or "5 + 2". Many gave the answer as 7.24 but this was accepted.
In (ii) which asked for the latest time at which the maximum value occurred, the most common mistake was setting the function = 0 and solving for *t*. Of those that understood the question, most students that solved this part set $15t$ - “26.6” = 90 but neglected the ‘= 270’ option and so

gained one mark only. A number set $15t$ - "26.6" = 1. Where the student did solve for both times, then the correct higher value was invariably identified as the answer to the question. However, only one mark of two was earned by the majority of students attempting part c(ii).

Question 11

(a) As well as the required solution of $\sqrt{(3/2)}$ many students included values outside the given interval (but still gained the mark), including 0 or writing $\pm\sqrt{(3/2)}$, or often the equivalent $\pm\sqrt{6}/2$. A small number gave the solution $x = \pi/2$ from incorrectly solving $\tan(\frac{1}{2}x) = 0$. Many gave only the answer $x = 0$ failing to realise this was outside the domain and that solving $(2x^2 - 3) = 0$ was required.
(b) It should be noted that a number of students omitted part (b) of this question and also that more students need to realise that clear working with details of each step are necessary in a "show that" question. Most understood the product rule for differentiation was required but few quoted the rule. However, many were able to write down the derivative correctly immediately, gaining the first three marks, although a few omitted the factor of ½ from differentiating $\tan(\frac{1}{2}x)$ and, having one correct term, scored 2 marks out of 3. From their derivative a significant number did not use the required identities and sometimes gave up and just wrote down the given answer. Some used identities in the expression and then did no more work in (b). Three marks out of six for (b) was common. A number of students, after insufficient or erroneous work, simply wrote down the given result.

(c) This part was done well. Students gained the M mark for substituting into the iterative formula. A common incorrect answer of 2.07 arose from their calculator being in degree mode. Decimals were usually corrected accurately and given to the required accuracy of 4dp, or, if not rounded were correct to 4dp. A few carried out an extra iteration in this part.

(d) Most gained the first M mark as sight of the correct ends of the interval [0.72825, 0.72835] was enough to gain this mark. However, a number continued with more iterations continuing from part (c) and so scored no marks in (d). Fewer gained the A mark for which more work was required. Errors included both using the original $f(x)$ from part (a), as well as incorrect calculations using a suitable function, and failing to state both change of sign and a conclusion, or sometimes using the calculator in the wrong mode. A few observed a sign change when there wasn't one (when using the original $f(x)$) and concluded that the root was in the interval. Others merely assumed a change of sign without writing down the results of the necessary calculations, and so clearly knew the underlying theory.

Question 12

The students generally struggled with this question, with a high number of blank or almost blank responses. In fact it was quite rare for students to score full marks on this question. The given answers in (a) and (b) helped many to get going, but often the answers had been manipulated to achieve them rather than from correct working.

(a) Students found this part quite demanding and often did not show an understanding of the problem. Some wrote down two values of d*V*/d*t* (rate of change of volume in, rate of change of volume out) and did not combine them to find the correct expression for the overall rate of change of volume. A number of students found the correct expression for d*V*/d*t* but did not identify it as such; sometimes it was embedded in their use of the chain rule. Those who understood the chain rule were usually successful once they had found d*V*/d*t* to be $(0.4\pi - 0.2\pi\sqrt{h})$. $dV/dh = 4\pi$ was usually found, although there were still some students using poor or incorrect notation. One mistake was to write down the wrong volume formula, usually having a factor of 1/3, and another was to wrongly differentiate the correct formula with respect to *r*. Students were more successful at using the chain rule correctly, even when their derivatives were incorrect, or sometimes correct but not stated before applying the rule. This was a given answer and some students manipulated their incorrect working to arrive at the given answer. For those who first found the correct expressions for d*V*/d*t* and d*V*/d*h*, most went on to get a fully correct answer, and clearly knew how to form a differential equation.
Some found the expression for d*V*/d*t*, but then set $V = t$, multiplied by their expression and so never formed a differential equation. Sometimes, what looked like a correct answer appeared, but clearly these responses were from an incorrect method and invariably scored no marks.

(b) This part also had a given answer with two marks available. Many students separated the variables of the expression given in (a) correctly and then formed the integral on the two sides to obtain the given answer. Although this was a fairly easy part to the question, some students lost 1 or both marks. The most common mistake was to omit the d*t* on the other side of the equation to the one with d*h*. Also students often lost the A mark by not writing in full the correct (given) integral at the end: quite a few students omitted including the d*h*. Several students felt they needed to perform some integration. A very few separated the variables but then wrote

$$\int 20\frac{\mathrm{d}h}{2-\sqrt{h}} = \int 0 \,\mathrm{d}t\,.$$

(c) For students who struggled with parts (a) and (b), this was the part where they were able to claim at least a couple of marks, although some did not even attempt it. Most students achieved the B mark by correctly finding d*h*/d*x*, although there were a few with sign errors here. A good proportion were then able to go on to produce an integral just in *x* by substituting their expression in *x* and d*x* for d*h* and expression in *x* for *h*; just a few simply changed the d*h* to d*x* which meant that no further marks were available in these cases. Not all had substituted d*h*/d*x* correctly but could still gain the method mark; a common mistake was placing the '$-2(2-x)$' in the denominator instead of the numerator. Some had simplified "$-2(2 - x)$" incorrectly before substituting into the integral but this allowed B1 and M1 still. Some incorrectly simplified the denominator "$2 - (2 - x)$" to "$-x$" having substituted $(2 - x)$ for $\sqrt{h}$, and this led to loss of the two

A marks. Some students earned the first two marks only as they did not change their integral into the form A/x + B, leading to incorrect attempts at integration. Most of the students obtaining the required form were then able to get the next marks by correctly integrating to A ln x + Bx and progress to substituting in the limits, most having changed the limits to x from h. Just a few students substituted h back in to the equation at this time and used the original limits to achieve the correct result. It was encouraging to see the number of students who changed the limits correctly and subtracted the right way around. Very few left the answer in its exact form; most wrote '49' without showing their components from each limit or the answer before rounding. It was interesting that some student converted the limits correctly but placed them incorrectly, as though the greater value had to be the upper limit. Some students however did correctly place the limits this way having reversed the sign of the integrand.
Having arrived at an integral of the form $(a + Bx)/x$ a few students attempted integration by parts but this was rarely successful. Also, different substitutions were used on a few occasions, usually $t = \sqrt{h}$, which could, but usually did not, lead to a correct solution.

Question 13

(a) This is usually an accessible question where students gain full marks, but surprisingly there were a number of students who were unsuccessful. Some substituted $t = 0$ into the formula but did not evaluate the expression, leaving it as 200 – 160/16. 200 – 160/15 = 189 was a common error. Some did not seem to know that $e^0 = 1$.

(b) The first mark was accessible and most students achieved this for differentiating e^{kt} as ae^{kt} anywhere in their dP/dt. The majority of students applied the quotient rule or less common, the product rule, correctly although there were a minority who added instead of subtracted the terms in the numerator. The presence of a minus sign in front of the expression to be differentiated caused problems, as this was often left out, losing them the accuracy mark. Some omitted the square term in the denominator in an otherwise correct numerator. It was disappointing to see how many students omitted the brackets in $(15 + e^{0.8t})$, even though they sometimes recovered and gave the correct answer in later work. Although all the marks could be gained for an unsimplified dP/dt, most did go on to simplify.

(c) This part of the question was considerably more demanding and required the numerator of dP/dt to be simplified. Students were successful in setting their numerator in part (b) equal to 0, and were able to recover from sign errors made in part (b). However, collecting the e terms and reaching $e^{0.8t} = 45$, proved more of a challenge. Sign errors were common and there were frequent problems dealing with multiplying the exponential terms. Weaker students multiplied the indices instead of adding them. Taking ln of both sides before collecting the e terms was quite common, and an equation of the form $A + B = C$ leading to $\log A + \log B = \log C$ was a seen quite often. A method mark was available for the correct order of operations moving from $e^{kt} = A$ to $t = 1/k \ln A$ and some gained this as their only mark in this part. However, students getting $e^{kt} = -A$ sometimes attempted to take lns of negative values, or sometimes the negative sign seemed to just disappear.

Question 14

This was found to be the most demanding question with many students unable to make any headway with (c) and (d). (a) and (b) were, however, accessible to most.

a) The vast majority evaluated the x and y coordinates correctly.

b) Most students knew they had to get the required fraction but their skills in differentiating composite trigonometric functions were sadly lacking. Some differentiated successfully using the chain rule but some, however, used the double angle formula before differentiating the parametric form of x also had to use the product rule - most of these students made errors along the way. Most students knew how to get the gradient of the normal and proceeded to find the equation of the line even if they had made previous errors. Those with an incorrect dy/dx often scored all three method marks. Some recognized they needed a gradient of -1 from their derivative and tried to fudge this from their wrong expressions. The few students who tried to use the Cartesian method were sometimes successful in part (b) – but could not progress to part (c).

(c) Students were able to understand what was needed for the area integral but success here was largely affected by their ability to differentiate the composite trigonometric expression, so many gained nothing in this part. Some lost the A mark for failing to put $d\theta$. Many who got the first 1 or 2 marks could not make any further progress in this question. Some did find the area of the trapezium, including those who did so by integrating, but many struggled to produce an expression in an integrable form. Some who were successful with this were still unable to deal with the limits and sign change to get the final mark.

d) Correct solutions here were very rare. Most made no attempt at this part of the question. For many that did attempt it, the integration proved too challenging and resulted in a lot of work on incorrect methods that gained no marks. A disappointing number of students managed to have 148 as part of their evaluation of 4 + 144[integral]. Some had used their calculator to work out the answer as they had shown no working and therefore scored no marks. It is possible that a number of students had run out of time as a small minority made no attempt at this question.

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