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In Core Mathematics C34 (WMA02/01)

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General Introduction

The paper provided students with the opportunity to apply their knowledge to topics across the whole specification. The questions were generally accessible to all candidates, though some questions provided a good challenge for the more able. Candidates' presentation was mostly good, though candidates should try to write unknown x in the "curly" form, to avoid confusion with the multiplication sign.
There were some examples where students let themselves down with careless algebraic processing errors. This was particularly evident in questions 8c and 12b. It was also evident that students were not aware of issues raised in previous examiners' reports with a particular example being the form of the answer required in question 6a.

Question 1

The first two parts of this question gave good access for the majority of candidates, with the $R\cos(\theta + \alpha)$ topic being well learned by most. The latter parts proved more challenging but were still approached well by many. There were very few cases of the use of radians instead of degrees in this question.
In part (a) the method needed was shown to be well understood, with the vast majority of students gaining full marks. Occasional cases of R being given inexactly as a decimal did occur (usually when α had been found first), but the most common error made where a mark was lost was due to an incorrect value for tan α being formed (usually 7/2, but −2/7 or −7/2 were also seen). Another, but more rare error, was $R = \sqrt{7^2 - 2^2}$ being used. On a few occasions, accuracy was lost on the value of α: 15.94 or 15.9 were seen.
Part (b) was again generally well done, with the first two marks being gained by the majority. Obtaining the second solution was done well by most, though some candidates failed to find a second at all, while others had a flawed method for finding a second solution. These included attempt to add 90º to the principal arcsin value before finding θ and incorrect rearrangement in subtracting the value of α before subtracting from 180º to get the second angle. Accuracy and rounding was mostly fine, but answers of 24.7º and 81.4º were not uncommon to see.
For part (c) the first mark was gained by the majority of candidates. The method mark was less well attempted, but still gained by most, though errors in signs often prevented candidates from gaining the accuracy mark. A number of candidates tried convoluted methods for finding the values of b and c through two or three identities and with varying degrees of success.
Part (d) proved much more challenging. Though there were many correct answers, there were as many incorrect or non-attempts at this question. Understanding the connection between the preceding parts and part (d) was not shown by many, with many attempts to instead try and solve an equation to find a value for θ and use this value in the given expression.

Question 2

This question provided another good early challenge in the paper while still remaining accessible to all candidates. Most candidates obtained fully correct solutions in part (a) and part (b) offered good discrimination for the more able candidates. There were many very well presented solutions that demonstrated an excellent understanding of the various mathematical skills involved.
In part (a) most candidates were able to identify the coefficient A correctly, though some assumed it was zero. This was achieved by various methods such as recognition, combining to a single fraction or by dividing $3x^2 + 4x - 7$ by $x^2 - 2x - 3$. Long division was the most common method and

candidates seem well trained to take this approach even though directly forming an identity is often easier. The most common cause of error in this part, made by a significant portion of candidates, was an error in the division resulting in an incorrect remainder.
Finding the coefficients B and C was also well done, whether from the original identity or as the result of long division, however there were a small number of candidates who either ignored the A in their cross multiplying in the identity or some who performed the long division but them reverted back to the original expression and omitted A.
To find the values of B and C, most substituted values of x, with comparing of coefficients being much less common.
In part (b) most candidates began well, using the binomial expansion for $1/(1 + x)$ correctly. However, expanding $1/(x – 3)$ correctly proved more challenging and consequently this was main source of lost marks. In particular, correct treatment of the minus sign and identifying the correct factor to be taken outside the bracket were common stumbling blocks for many candidates, as was swapping the order of terms in order to have a viable expansion. Many attempted to simply expand is if it were already in the correct form, achieving a variety of incorrect expressions. Use of direct expansion was rare, but there were attempts seen at expanding $\left(-1+\frac{x}{3}\right)^{-1}$ after attempts at taking out the factor 3, some of which were correct.
Most candidates followed the work in part (a) by using their partial fraction expansion with their expansion to gain the final method mark even when the expansions were not correct. Where candidates chose to multiply out all 3 brackets for the final method mark, arithmetic and sign slips, more often than not, led to incorrect answers. This part proved an excellent source of marks for well-prepared candidates.

Question 3

For this question the first part was the more challenging, with many correct attempts at part (b) seen, but very few at part (a). Domains and ranges continue to be a topic that is not well understood. In part (a) only a small percentage of candidates gained full marks, although most were able to gain at least one mark. Attempting $f(-4k)$ was the most common source of marks, but in some cases either the evaluation was incorrect, or not associated with the correct end of the range, so only one mark was gained. There were fewer attempts at $f(-3k/4)$, and even when this was attempted, often the other end of the range was not. Candidates seemed to have the idea either that both end points needed checking, or that the value at the vertex was needed and so did one or the other.
A number of candidates did identify $x = -3k/4$ as a key value, without knowing what to do with it, either using this value as the end point, or going no further.
For those who attempted to complete the square, the factor of 2 often caused errors in the constant term, and hence errors in the minimum value given. There were also some candidates who completed the square correctly and then did not know how to use their result.
Part (b) was very well done, with many fully correct responses. Nearly all candidates could apply the functions in the correct order, then form and solve the required equation. Attempts at $f(-2) = g^{-1}(-12)$ we rare, but also generally correct. A few set their $gf(-2)$ equal to 12 or even 0 rather than -12 or made an error in forming their three-term quadratic which resulted in the wrong answers. Candidates were usually able to solve their three-term quadratic to find the two values of k. Most candidates obtained the correct answers.

Question 4

The majority of students gained full marks in part (a). Where students did not gain full marks it was mostly due to incorrect implicit differentiation, usually for example failing to write $\frac{dy}{dx}$ with the appropriate terms or failing to negotiate the product rule correctly.

Other errors made were: $81y^3$ differentiated as $243y\frac{dy}{dx}$, leaving out 256 or sign slips.

Some failed to differentiate $64x^2y$ correctly, not getting the $64x^2\frac{dy}{dx}$ term, and so lost the third method mark by not having two $\frac{dy}{dx}$ terms to collect on one side.

Very few started with an extra $\frac{dy}{dx} =$ and even fewer continued to include this extra term in their algebra. A small number made sign errors in their final answer, after rearranging.

With some errors in (a), it was possible to gain full marks in part (b) (if the numerator of the fraction was correct). Almost all equated their numerator to zero to gain the first mark. A few of these had $128x$ or $128y$ rather than $128xy$. A small number lost the minus sign and substituted $2/y$ rather than $-2/y$. A few could not proceed to $x^4 = ...$ after substituting and achieving an equation involving x^3 and x. Very few reached x^4 = a negative constant. Most found the root correctly but a few took a square root. A large number of candidates found only the positive root rather than both roots. This was the most common error in this part of the question. Almost all went on to find the other matching coordinate. Many who had made errors earlier gained the method mark for finding the second coordinate. Only a very small number of responses recorded the coordinates as (y, x).

Question 5

Part (a) was quite well answered with many candidates scoring full marks. Most knew that $\sec^2 x = 1 + \tan^2 x$ although some thought that $\sec^2 x = 1 - \tan^2 x$ and some even believed that $\sec^2 x = \tan x$. Incorrect algebra for the $\tan y$ term was common. Those who recognised that $16\tan^2 y = (4 \tan y)^2 = (8m + 5)^2$ were generally more successful than those who used $\tan y = (8m + 5)/4$. It was disappointing to see $(8m + 5)^2 = 64m^2 + 25$ on many occasions which meant that the resulting quadratic was not 3 term.
There were two popular approaches in part (b) to find an exact value for sin. These were using trigonometric identities and using SOH-CAH-TOA rules by drawing right angled triangles. Of these two methods, the latter was far more successful. Candidates struggled to manipulate combinations of correct trigonometric identities into a single one connecting sin and tan.
It was common to see $\sin(\tan^{-1}\ldots)$ as a method. It was also fairly common to see two values given for the answer, using the negative value of m also.
In part (c) candidates were generally more successful in establishing a value for $\cot y$. Again it was common to see two values given for the answer. A few found answers in terms of m without making a numerical substitution.

Question 6

Candidates found this one of the more difficult questions on the paper. A good number of responses were blank.

In part (a) many found the correct direction vector by subtracting **OA** from **OB**, with a small number subtracting **OB** from **OA**. A small number made an error with one component but still gained this method mark. Many failed to write '**r** =', losing the A mark despite this being highlighted in previous reports. The majority wrote 'l =' or 'l :' instead. A significant number just gave vector **AB** as their final answer. Some failed to find a direction vector and gave e.g. $\mathbf{r} = 2\mathbf{i} + \mathbf{j} + 9\mathbf{k} + \lambda(5\mathbf{i} + 2\mathbf{j} + 7\mathbf{k})$ as their answer.

In part (b) very few candidates showed any method for finding the vector **AC**. The third component was seen recorded as '12' a few times. The scalar product was carried out well with the majority achieving full marks. A common error here involved incorrect multiplication of the **k** components, leading to an answer of 69.1°. The cosine rule and vector product methods were not seen.

Part (c) proved to be a good discriminator. Most candidates failed to draw a sketch of the problem and as such couldn't recognise which vectors were needed in forming the dot product for Way 1 on the mark scheme, which was by far the most popular method chosen. Many used the general point on the line (i.e. the position vector of *D*) without subtracting the vector **OC** but many others used the vector **AC** correctly. Some of the incorrect answers seemed to draw on aspects of more than one method, in particular confusing aspects of Way 2 and Way 3 of the markscheme. Most who reached incorrect, usually fractional values for λ could substitute to find coordinates of *D* but were unable to gain the double dependent third method mark due to earlier incorrect work. Many attempting Way 2 or Way 3 scored all the method marks but almost all lost the accuracy mark as they recorded two answers for *D*.

In part (d), two correct methods were seen in roughly equal measure:
$\frac{1}{2} \times AC \times CD$ and $\frac{1}{2} \times AD \times CD \times sin60°$. Some wrote $\frac{1}{2} \times AC \times CD \times sin90°$.
A number used the length of *OD* rather than *AD* or *CD* and lost both marks. Other common incorrect methods were:
$\frac{1}{2} \times AC \times AB \times sin60°$ and $\frac{1}{2} \times AC \times CD \times sin60°$.
Many of those with an incorrect *D* from part (c) still managed to subtract *A* (or *C*), and could gain the method mark although they often had a harder task with awkward components.
It was interesting to see some candidates who had lost marks in the rest of the question answer this part well, not relying on the coordinates of *D*, but instead working out the length *AD* or *CD* using trigonometry.

Question 7

In part (a) many candidates were able to correctly find the area using the trapezium rule with most using surds until the final value. Most of the less successful candidates understood the structure required for the method mark but were not always using the appropriate number of ordinates. Some candidates were attempting to use 2 strips instead of the required 4 strips so could only score the method mark for the correct structure of the *y* values. A few used 3 strips with $h = 2/3$ and a few used the correct width but started at $x = 4.5$ or finished at $x = 5.5$. There were a few instances, in particular when decimals were used, where figures were mis-copied. There were also a few cases where candidates obtained the right numerical expression but failed to evaluate the final answer correctly. A number of candidates rounded to 9.13 rather than 9.14 despite the rest of the working being correct.

Fully correct answers in part (b) were relatively rare. Most candidates were able to differentiate the substitution to gain a correct value for $\frac{du}{dx}$ or an equivalent accurate replacement for d*x* in the integral and many tried to substitute fully but errors were often seen such as omitting the 7, omitting "√" in the denominator, using 2d*u* instead of ½d*u* or rearranging to get $x = \frac{u-3}{2}$ instead of $x = \frac{u+3}{2}$.
A significant number who had substituted correctly then made errors manipulating the fractions or dealing with the denominator ready for integrating so few achieved the 2nd accuracy mark.
Examples included ½/2 = 1 instead of ¼, ½(u + 3) + 7 = ½u + 10.
Some very poor attempts at integrating were seen with a few candidates still having both variables in. Use of ln was not uncommon eg $\int 17/(4\sqrt{u})\, du = 17\ln(4\sqrt{u})$.

Many candidates changed the limits to the correct values for u and went on to gain the final method mark for substituting and subtracting. There were sign and numerical slips here also. Decimal answers were seen occasionally. Only a small minority replaced u back in terms of x and then used the original limits. A small number used 6 and 4 in their integral in terms of u.
A few candidates integrated by parts without substitution and had varying levels of success with this approach.

Question 8

(a) This was generally well answered, $\frac{dx}{dt}$ was generally correct (occasionally the error $2t$ was seen), $\frac{dy}{dt}$ caused a few more issues mainly in the simplification of their correctly differentiated expression, especially when the product rule was used instead of the quotient rule. A few sign errors were seen giving e.g. $\frac{dy}{dt} = \frac{4-8t}{(1-t)^2}$.
Some candidates incorrectly gave e.g. $4t\,(-1)(1-t)^{-2}(-1)$ or $4(-1)(1-t)^{-2}$ perhaps seeing it as a chain rule or a product where $(uv)' = u'v'$.
The majority of candidates successfully progressed to $\frac{dy}{dx}$ but a few candidates multiplied by $\frac{dx}{dt}$ instead of dividing. A few candidates unnecessarily multiplied out the brackets on the denominator.

In part (b) the majority of candidates knew what they had to do. The main error was finding the x coordinate when $t = -1$, $x = t^2 - t$ often became $x = 1 - 1 = 0$.
Candidates who had simplified their $\frac{dy}{dx}$ incorrectly in (a) were able to gain a mark for correctly using this in (b) if they showed $t = -1$ substituted into so candidates should be reminded of the importance of clearly showing their working. The equation of the tangent was successfully found by those with the correct values.
Most errors were seen in attempts to use $y = mx + c$, rather than $y - y_1 = m(x - x_1)$

Part (c) was poorly answered overall and many left this part blank. However many candidates substituted the parametric equations into their equation of the tangent. There were many errors when manipulating the resulting equation into a cubic equation for t and then no more marks were scored. Candidates who obtained the correct cubic often went on to find the correct value of t either by making use of a calculator to solve the cubic (the quickest method) or recognising that $(t + 1)$ is a factor and used long division to find the quadratic component and then solve it. However even some candidates who did get to the right cubic didn't know how to proceed to solve the cubic.
Some candidates tried to eliminate t from the parametric equations, usually finding $t = \frac{y}{4+y}$ then $x = \left(\frac{y}{4+y}\right)^2 - \frac{y}{4+y}$ and substituted into their equation of the tangent. This often led to errors with the algebra involved. On the rare occasion that the correct cubic equation in y was obtained they often went on to find the correct y coordinate making use of a calculator to solve the cubic successfully. Candidates with an incorrect tangent equation were still able to gain method marks in (c) if they formed an equation in one variable and attempted to solve their cubic using the fact that $(t + 1)$ must be factor.

Question 9

This question tested a mix of integration techniques, of which candidates succeeded better with integration by parts than with dealing with the trigonometric integral of $\sin^2(2x)$.
In part(a) most candidates recognised that the expression to be integrated was a product and attempted to use the formula in a correct manner. The majority of responses were fully correct. In those that were not, the most common errors were either with the sign or the coefficient of the terms but with the general form correct. A few responses gained no marks. These either applied the parts formula incorrectly, ending up with a sin term at the first stage, or failed to attempt parts at all, integrating each term of the product, or attempting an incorrect product rule.

For part (b) the first task was to expand the brackets, giving a fairly straightforward mark to most candidates. However, a significant proportion of students failed to even do this, instead attempting a "chain rule" for integration. These attempts not only lost all marks for (b) but meant at most one mark was available in part (c) too. A number attempted to find the integral by a substitution method. In a very small number of cases integration by parts twice was carried out sometimes resulting in an equivalent correct answer for the integral.
Most candidates did realise the need to square out the bracket before trying to integrate the given expression, and these expansions were for the most part correct. There were some careless errors in copying down the trig term with the '2' from the sin $2x$ sometimes missing.
Once expanded, integration of the x^2 term was universally performed correctly. For the $2x\sin2x$ term, most recognised this was twice the answer to (a), although some did not double, while others performed the integration steps from part (a) once again. Dealing with the $\sin^2(2x)$ term however, is a technique that candidates should be more aware of. Only about half of candidates were able to deal with this successfully, with many ending up with $k\sin^3(2x)$ as the integral for some k. Others attempted a double angle formulae without doubling the angle, or forgot to half the result.

In part (c) the first mark was gained by most candidates, with only very few omitting the π or failing to square y before integrating. Access to the second mark depended on the attempt made in part (b), but the idea of substituting the limits was evident for the majority of candidates. Some good candidates lost the final mark because even though they had a correct value for the volume, they failed to express it as a single fraction as specified in the question.

Question 10

This question proved another discriminating question on the paper, particular in the first part. Although the vast majority of candidates recognised the need for the chain rule, very few were able to apply it with a correct $\mathrm{d}V/\mathrm{d}h$. Most failed to find a connection between r and h at all, and treated r as a constant in the volume formula. In many cases where a connection between r and h was found, this was not applied until after applying the chain rule and so the first and second method marks were lost by most candidates. Others substituted $r = 3$ first to try to get around the problem of two variables, and $k = 6$ was a common incorrect answer.
The third method mark was gained by most with a correct and appropriate chain rule used with $\mathrm{d}V/\mathrm{d}t = \pm 0.02$ being used. Many candidates, even among those formed a correct equation for V in terms of h, did not recognise that $\mathrm{d}V/\mathrm{d}t$ needed to be negative and used the positive value before making their answer negative to match the printed result.
Attempts at part (b) were much more successful with most candidates able to integrate the expression from part (a) and secure the first mark. Most went on to evaluate their constant of integration using $t = 0$ and $h = 5$, although a few forgot it entirely and lost the second method mark. There were some instance of poor algebra in rearranging to $h = \ldots$, leading to the constant of integration ending up outside of the cube root.

A minority of candidates took the alternate approach using V= $15\pi - 0.02t = \frac{1}{3}\pi r^2$ h and rearranging this equation to make h the subject. This method also required substituting $r = 3h/5$ which had eluded so many candidates in part (a). Full marks would have been common in part (b) had it not been for the fact that relatively few candidates started with the correct value of k.
In part (c) those candidates who had made some progress with part (b) usually went on to gain at least the method mark. Those who had a constant of integration gained this by substitution of $h = 0$ into their equation, while those who did not have a constant of integration could still obtain the method via the alternative method using limits of integration since the lower limits did not need to be seen. However, it is doubtful if the majority of students scoring via this approach realised why it worked by substituting $h = 5$ at this stage, and would be advised to remember the constant of integration since this alternative method would not be successful if the lower limits were non-zero. The alternative approach of dividing 15π by 0.02 was also seen fairly often; candidates who had not made much progress with the rest of the question understandably tended towards this method. Overall there was a wide range of marks for this question and some candidates didn't attempt this question at all.

Question 11

Throughout this question it was apparent that some candidates did not know what arccos and arctan meant with some candidates actually writing words to this effect on their scripts.

Part (a) was poorly done with many candidates getting zero marks. Very few candidates scored both of the available marks. Some candidates drew the cosine graph and some drew sec. Of those who knew what the arccos x graph looked like, the common errors were to not translate it or draw too many cycles. The quality of candidates' freehand drawing was poor. On occasion when a candidate almost had a correct answer, their graph did not touch the axes at both ends.
Candidates were more successful in part (b). The common errors were not making a "sign change" comment, not making a conclusion or mis-evaluating at one or both values. A significant number of candidates thought that they needed to solve the given equation rather than simply substituting values.
Part (c) was very well done with most candidates getting both marks. The most common error was to give the final iteration as 1.01 (3SF) instead of 1.011 (3DP).
The use of degrees was sometimes seen in both parts (b) and (c).

Question 12

The majority of candidates showed a knowledge that the modulus graph is a V shape, but identifying where it was placed in this instance, and what the intercepts were, was not always done well. There were a small number of cases of inverted or sideways V's or graphs with extra branches, but the shape was correct in most cases. In most of these cases, the vertex was on the y axis, giving the first mark, though some had the vertex in the fourth quadrant.
The intercepts were less well attempted, with a variety of incorrect intercepts given. Common mistakes for the vertex was to have the y intercept at $2 - k$ or at k while for the x intercepts, sign errors, or $\pm 2k$ occurred frequently. A small number of candidate did label correct intercepts despite having the vertex of the graph in the fourth quadrant.
Part (b) was well attempted by the majority, even following incorrect sketches in part (a). The idea of using $|x|$ as x and then $-x$ was well understood, although in some cases only the first of these was attempted. The algebra was generally correct in the rearrangements although careless slips were

sometimes made. A small number of candidates made x the subject instead of k, and so lost the accuracy marks as a result. Attempts at squaring the equation were largely unsuccessful, though some did succeed in finding both solutions this way, if they remembered to rearrange before squaring.

Question 13

The final question on the paper once again provided an accessible start, but ended with a discriminating part to challenge the best students. Being the end of the paper there were a number of incomplete responses, which may have been due to time pressures but most at least attempted the first two parts. A small number of candidates misread the power to be positive rather than negative, while some misread the 16 as 10.

Part (a) provided little challenge, with almost all candidates who attempted the question gaining both marks. A very small number of candidates used $t = 1$ instead of $t = 0$, either intentionally or through confusion of what e^0 is, while algebraic slips in the rearrangement were seldom seen.

In part (b) there were again many fully correct solutions. Generally the manipulation and taking logs were done in the right order. The misreads of the power were the most common source for the loss of the accuracy mark, though these could still gain both methods. Miscopying between lines was also not uncommon, with 7/19 becoming 17/9 or similar being seen a few times.

Part (c) proved to be a much more challenging part, with a variety of ways to proceed, and as noted there were some candidates who seemed to be under time pressure and did not complete this although they appeared to be on the right track. It was possible to gain most of the marks in this from the common misread of a positive power as the only difference it made was in the sign.

Most candidates attempted to differentiate the expression as given, either using the chain rule or quotient rule. Errors in differentiation were common, particularly using the quotient rule and forgetting to differentiate the "240", or making a sign error, or omitting the factor k. Bringing an extra t down from the power or attempting to subtract 1 from the power of the exponential were also common.

Those who differentiated correctly sometimes continued in an attempt to write the answer in terms of N, but many gave up at that point. Those who did continue had a variety of methods; some substituted directly into their expression and others manipulated the expression first using long division or partial fraction – type methods. There was a lot of scope for arithmetic or algebraic errors but there were some correct solutions.

Another common approach involved first making t the subject, and this was often approached well. The success of the differentiation via this method often depended on the form reached. Those who applied the subtraction law of logarithms to reach $t = 16\ln k + 16\ln N - 16\ln(240 - N)$ or similar first were more successful that those who left it as the logarithm of a quotient, as these would make errors in applying the chain rule. While there were many successful attempts via this method it is noteworthy that many students, when reciprocating to find $\mathrm{d}N/\mathrm{d}t$, thought that to reciprocate an expression you just needed to reciprocate each term, and thus did not complete successfully.

Less common were attempts at partial rearrangements and implicit differentiation. Those attempting such methods were mainly successful. Some approaches this via these routes automatically obtained the derivative in terms N, circumventing the need to eliminate t, which was the aspect of the question that candidates found most difficult in this part. Fully correct answers to this question were rare, making it a good discriminating question to end the paper.

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