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General Comments

This paper provided a variety of challenge and discrimination across the questions covering the specification for this unit, and learners were able to make attempts at all the questions. There were some questions which learners found particularly challenging, however, namely Questions 5(b)(ii), 7(b), 9(a) and 10. There are still a significant number of responses where learners have not shown sufficient working despite the warnings at the start of the question. This resulted in a number of marks not being gained. Learners should be reminded that the warning "the use of calculator technology is not acceptable" indicates that they should be showing their method in solving a quadratic equation for example, rather than just stating the roots.

Question 1

This question focused on sequences, with particular emphasis on recurrence relations. It proved to be a positive start to the paper and was attempted by almost all learners, with many demonstrating a sound understanding and gaining full marks.

In part (a), learners were usually successful in finding expressions for the second and third terms of the recurrence relation. Most understood the requirement and achieved the correct expressions. A common error was an incorrect attempt to simplify the third term by multiplying throughout by the denominator of the fractional term. While this was condoned at this stage, it prevented the final accuracy mark from being gained in part (b).

In part (b), learners were required to set their answer from part (a) equal to 6 and manipulate the resulting equation to form and solve a quadratic equation. Most learners recognised the need to set their expression equal to 6. In some instances, an error in part (a) meant learners were unable to reach a quadratic equation and therefore did not gain marks in this part. However, many learners successfully

formed a quadratic equation and achieved the first method mark. A calculator warning applied to this question, meaning learners needed to show a valid method for solving their quadratic equation in order to gain the final two marks. Not all learners recognised this requirement, and as a result, some who had the correct answers did not score the marks.

Question 2

This question on the binomial expansion was generally answered extremely well and many learners obtained full marks. Surprisingly, however, some learners did not attempt this question. Some learners did not score one of the marks due to a sign error, whilst errors in bracketing prevented others from scoring full marks. It was rare to see learners manipulating the expression to the form $(1+x)^n$, but those that did use this form were mostly able to achieve the correct answer.

Question 3

The trapezium rule continues to be a topic that learners generally handle well in exams, and this session was no exception. Most learners made strong attempts at this question.

In part (a) learners largely applied the correct form of the trapezium rule, with only a small number making minor errors, such as incorrect use of brackets. However, some appeared to struggle to identify the correct width (*h*), with the most common mistake being the use of $\frac{b-a}{n}$ where $n=4$. Despite this, the majority achieved full marks in this section.

In part (b) learners were often successful in using their part (a) answer to some

extent, although learners that did not therefore did not score any marks due to the fact they tried to redo the trapezium rule from scratch, or attempted integration. A number of learners achieved full marks in this part, including those who had made an error in (a), due to the follow through on the accuracy. For those who did not achieve full marks, many achieved the first method mark. The more successful strategy for gaining this mark was finding the +9 that was needed to be added to the part (a) solution. Learners often showed the integration stage for this, but others just showed the numerical calculation. Other learners appreciated that the second term of the integral would produce a value that was half of the magnitude of (a), however they simply added 1 without acknowledging the need to integrate between the given limits.

Question 4

This question provided a good opportunity for learners to demonstrate their understanding of factorising non-quadratic polynomials and the relationship between factors and equation roots. The structure of the question allowed learners to show fluency in algebraic manipulation, substitution and reasoning about the number of solutions.

Part (a) was generally well attempted, with most learners recognising the significance of the given factor $(x+3)$ and substituting $x=-3$ into the cubic expression to form an equation in k. The majority of learners were able to proceed correctly from this point and obtain a value for k. Marks were often not scored when omitting the equality to zero after substituting $x=-3$. Learners who wrote only a numerical expression, rather than an equation equal to zero, did not score the first method mark. A further substantial group of learners stated the quadratic's roots without showing any working, despite explicit instructions to do so. These responses consequently lost the final two marks. A minority approached the question by substituting $k=5$ to verify the factor condition, and this method was generally successful when clearly justified. Solving the resulting

quadratic was commonly done by factorisation, although some learners opted for methods such as the quadratic formula or completing the square. A small but noticeable number produced factor pairs with signs inconsistent with their quadratic expression, implying reliance on calculators. In the most frequent case this was condoned by the mark scheme, but it nevertheless highlighted weaker algebraic reasoning.

In part (b)(i), the vast majority of learners successfully expanded the cubic expression as required. Only a small number stopped at the expanded cubic and did not proceed to factorisation, thereby not gaining some marks. Algebraic division was the most common and successful approach, with division by $(x+3)$ handled competently by nearly all who attempted it. This reliably produced the correct quadratic factor. A smaller proportion used inspection or reverse factorisation; when used, these methods were also generally sound. A few learners derived the correct quadratic factor but did not proceed to express the cubic in full factorised form. Such responses did not gain the final mark as they did not demonstrate understanding of the requirement to present the complete product of brackets.

In part (b)(ii), the performance by learners was more mixed, largely depending on whether learners had completed part (b)(i). Those who attempted the part typically used the discriminant to determine that the quadratic factor had no real roots, which was an appropriate and successful method. However, many learners lost the final mark because their conclusion referred only to the quadratic and did not acknowledge the root $x=-3$ already identified from the given factor. This showed incomplete execution of the instruction to "show there is only one root." Some learners attempted to state complex roots obtained via calculator, but this was not condoned. In such cases learners did not show they were able to appreciate why the presence of complex solutions implied the cubic had only one real root. A small number of responses did not complete basic calculations—for example leaving $81-84$ unevaluated rather than evaluating to -3. Candidates

should be reminded to use attention to detail to ensure their final argument is clear.

Question 5

This question tested learners' ability to solve equations involving logarithmic expressions. Overall, it was well answered by many learners, with a good number demonstrating sound understanding of the laws of logarithms and the algebraic techniques required.

In part (a), learners were usually successful in recognising the need to apply the addition and subtraction laws of logarithms. Many applied these laws correctly at least once, which enabled them to make progress towards the solution. Common misconceptions included errors when dealing with the "-1", with some learners incorrectly combining it with $\log_a 27$ to form $\log_a 26$. Sign errors were also relatively frequent, suggesting that some learners lacked confidence when manipulating logarithmic expressions. Those who removed the logarithms correctly often completed the question successfully. However, some learners produced an expression for a in terms of x rather than x in terms of a. , and others incorrectly handled the negative power, leading to answers such as $x = 9a$ instead of $x = \frac{9}{a}$.

Part (b) required learners to solve a quadratic equation in terms of $\log_5(y)$. A common error was to misinterpret the notation, treating $(\log_5 y)^2$ as $\log_5(y^2)$. Learners who made this error generally did not recover and did not gain credit in this part. Those who correctly identified the quadratic structure were able to proceed with appropriate methods and reach valid solutions.

This question carried a calculator warning, meaning learners were expected to show sufficient working to justify their answers without relying on calculator

functions. This required two clear steps: first, demonstrating a valid method for solving the quadratic equation, and second, showing how to evaluate y from the logarithmic equation. For example, from $\log_5 y = 3$, learners were expected to write $y = 5^3 = 125$. Centres are advised to ensure that learners are fully aware of the expectations in questions where calculator warnings are given, so that they provide complete solutions with appropriate reasoning.

Question 6

This question assessed learners' understanding of circles, including completing the square, identifying the centre and radius, and applying inequalities. Overall, parts (a) and (b) were well answered by most learners, while part (c) appeared more challenging and exposed several common errors.

In part (a), a large proportion of learners were successful in completing the square and identifying the centre of the circle. Most demonstrated confidence in this technique, and many achieved the correct result. Misconceptions were rare but those seen included giving the coordinates of the centre with incorrect signs, and errors when completing the square, generally reaching a centre of (6,14). A small number of learners did not attempt to complete the square.

In part (b), learners were again largely successful, with many correctly identifying the radius once the equation had been rearranged. Some learners made sign errors, reaching $\sqrt{26}$ as the answer rather than $\sqrt{90}$. Confusion between the radius and the radius squared was rare.

Part (c) required learners to determine the range of values for the constant term that ensured the circle lay entirely within the first quadrant. The problem-solving element proved challenging, and a significant number of learners made no attempt at this part. Among those who did attempt it, many recognised the need to use the radius to set up an inequality, but common errors were observed. These

included confusing the radius with the radius squared, leading to incorrect inequalities such as $58-k<3$ instead of $58-k<3^2$. Other frequent errors involved sign errors and, less commonly, substituting 7 as the radius rather than 3. Some learners identified only one of the necessary constraints, which prevented them from reaching a complete solution.

Question 7

This question provided a good opportunity for learners to demonstrate their understanding of trigonometric identities and their use in solving equations involving multiple trigonometric functions. The structure of the question enabled learners to show fluency in algebraic manipulation, the application of identities, solving quadratics, and finding multiple valid angle solutions.

Part (a) was generally well attempted. Most learners recognised the importance of dividing through by the cosine function in order to obtain a tangent expression. A number introduced a substitution for 2θ, and in most cases this was handled correctly, with the final solutions returned in terms of θ. The majority then used the inverse tangent function appropriately to obtain their first value of θ. However, a common error was to stop after finding the principal value, resulting in only one solution. Another frequent error was adding 180° to the value of θ, which led to an invalid second solution. Only a small minority attempted to work entirely in radians, and most learners did not rely on calculators to solve the original equation without steps - something that would not have gained credit. Some learners used alternative yet valid approaches, such as expanding the original expression using double-angle identities for sine and cosine in order to reduce the equation to a single trigonometric function. Although this method occasionally led to correct results, it also introduced spurious solutions, and marks were sometimes not gained when learners did not check or reject invalid answers.

A small number attempted the double-angle identity for tangent, forming a quadratic equation in $\tan\theta$. When used correctly, this method produced valid solutions, though it was less commonly seen. Errors in notation such as writing expressions like $\frac{\sin}{\cos}\theta$ lacked clarity and so learners should be reminded of the importance of clear presentation. Additionally, a number of learners truncated their solutions instead of rounding to the required degree of accuracy.

Part (b) was understood well by most learners. The majority correctly divided by $\cos x$ and used the Pythagorean identity to form the required quadratic equation in terms of $\sin x$. It was not uncommon for learners simply to state the roots of the quadratic; this was condoned on this occasion and did not prevent access to the available marks. Most learners recognised that the root of -5 was extraneous and correctly used the value $\frac{1}{5}$ to obtain the first solution. The process required to find the second solution was generally understood; however, many learners used rounded values from the first part of their working (e.g. using 0.201 instead of a more accurate value), which resulted in a second solution that did not round to the correct final answer. Overall, the manipulation of trigonometric identities was very successful in this part. Nevertheless, presentation errors were still present, with occasional expressions such as $\sin x^2$ appearing in place of $\sin^2 x$. These were condoned when the learner's intention was clear.

Question 8

This question provided an opportunity for learners to demonstrate their understanding of integration, the graphs of cubic functions, and the effects of graph transformations. The structure of the question required learners to reason carefully about the appropriate limits for the definite integral, and this proved to be an important discriminator between stronger and weaker responses.

Part (a) was well understood by most learners. The vast majority correctly expanded the product to form a cubic expression and then integrated term-by-term to obtain a quartic expression. Occasional slips were seen in the algebraic expansion, but these were generally condoned if the integration of the resulting cubic was carried out correctly. Most learners identified the correct limits for the definite integral and evaluated the expression successfully. A small number did not explicitly show the substitution of the limits; however, when the correct integral with limits was written and the final value of 486 obtained, this was accepted. Very few learners sketched the graph to support their reasoning. In this particular instance the cubic did not cross the x-axis between -2 and 4, so this omission did not affect the outcome. Nevertheless, with similar questions learners who do not consider the shape of the graph may make errors in the sign or meaning of the area. It was encouraging to see that learners generally followed the instruction to use algebraic integration. It was rare to see solutions relying solely on calculator-generated integral values, and when they appeared they were not credited unless accompanied by correct algebraic working.

Part (b) appeared challenging to many learners. Although most understood the premise of the question - to manipulate the transformed expression into a form that could be related back to part (a) – in some responses the algebraic manipulation was weak. A common error occurred when taking out common factors: many learners incorrectly obtained $\frac{3}{2}$ instead of the required $\frac{9}{2}$ because they mishandled indices or factored only partially. Most learners did recognise that the resulting scale factor should be applied to the answer from part (a), but errors in the factorisation inevitably led to incorrect final answers. Some learners separated the 9 and $\frac{1}{2}$ factors and worked step-by-step towards $\frac{9}{2}$; this was acceptable when complete and correct. However, learners who jumped directly

to $\frac{9}{2}$ without demonstrating the factorisation were not awarded the method mark. A minority expanded the transformed cubic fully and then attempted to factor out $\frac{9}{2}$. This occasionally produced the correct factor, but when learners then proceeded to integrate the new expression directly - rather than relating it back to part (a) - this was not condoned, as it did not show the required method. A number of learners left this part blank, suggesting either uncertainty with algebraic manipulation or a lack of recognition that the expression needed to be linked directly to part (a).

Question 9

This question required an application of knowledge to a geometric series and an analysis of an arithmetic series. The geometric series part of the question was generally done very well, but the analysis required on the arithmetic series seemed challenging as learners seemed unsure of a suitable approach.

In part (i), the geometric series information was interpreted mostly correctly and a correct equation in r^4 was often formed. There were a few misreads of fifth as fifteenth, which prevented accuracy marks from being scored. Most learners were then able to rearrange their equation to make r the subject and use this correctly in an expression for the second term. A common error of those who used the correct methods was to use a rounded value of r in their subsequent expression for the speed of the car in second gear which prevented scoring of the final accuracy mark. It was rare for learners to achieve no marks in this part of the question. Those that did was very usually down to no attempt being made, or incorrect use of the equation $ar^5 = 130$ with the wrong index for r. Some misinterpreted part (i) as an arithmetic series with both scoring no marks.

In part (ii)(a), learners generally did not demonstrate an effective strategy. Some initially miscalculated their difference as 0.8 rather than -0.8 which meant that

that they did not score. Due to the mention of the sum in the question, many learners went straight into finding a general formula for S_n in terms of n but then could not see a way forward from there and did not score in this part. Those learners that moved forward either differentiated or completed the square to find the turning point, which led to an n value of 260.5 surprisingly a number of learners did not appreciate the requirement of n to be an integer and thus scored no further marks. Learners that did acknowledge the requirement for n to be an integer did not seem to recognise the symmetry in the parabola and went on to calculate both $n = 260$ and $n = 261$ to find the correct sum value. Learners often chose to revert to the original formula for sum of an arithmetic series at this point rather than using their simplified quadratic. A very small minority of learners chose to sketch the quadratic they found after simplifying the sum formula and considered the middle value of n using the roots. Those that did this benefitted further as this sketch also helped them to interpret this part and the next part of the question. The most successful and efficient method, though not as common, was to find the value of n where the term of the sequence was zero (208/0.8) and substitute this value into the formula for the sum of an arithmetic series.

In part (ii)(b) those learners who drew a sketch or found the roots of the quadratic in the previous section could generally write down the correct value of n here and interpreted the question correctly. Many learners who did not find a quadratic in n previously had to work through and find roots for this part of the question as once again the symmetry of the parabola was not acknowledged, however many left their answer as an inequality and did not find the smallest value and therefore did not score. Those learners who did not interpret this part of the question correctly often opted to choose the next integer value finding where $n < 0$ instead of the required $S_n < 0$ to their answer in the previous part.

Question 10

This question on optimisation discriminated well between learners and was appropriately the most demanding question on the paper. Many who appeared to find the proof in part (a) challenging were able to use the given result to progress to parts (b) and (c). A small minority made no attempt at this question.

Part (a) was the more demanding part of the final question with the majority of learners not able to formulate a fully correct proof. Learners who were able to recall the standard formulae for arc length and sector area generally did well, although a common error was an incorrect coefficient, often confusing $(2r)^2$ with r^2. Learners who attempted to convert angles from degrees to radians could access all marks however they tended to be more likely to make errors, whilst a small number of learners worked in degrees and as such did not gain the accuracy marks. Learners completed the proof element of this question well, showing clearly their rearrangement of the area and substitution into the perimeter. Very few manipulation errors were seen.

In part (b), the majority of learners were able to correctly differentiate the expression for perimeter with respect to r, scoring the first two marks. Having obtained the value of r, which was almost always correct, a significant number of learners stopped there, and did not find a value for P. Some incorrect notation was seen, for example labelling the derivative as $\frac{\mathrm{d}y}{\mathrm{d}x}$, but on this occasion this was condoned.

In part (c), those who had a correct first derivative in part (b) nearly always went on to find the second derivative correctly and made reference to its sign or value at r to score the method mark. However, some justifications were insufficient to

score the accuracy mark, for example stating that $\frac{\mathrm{d}^2P}{\mathrm{d}r^2} > 0$ when $r = \frac{\sqrt{30}}{2}$ without substituting their value of r or considering its sign.