GCE EXAMINERS' REPORTS

GCE (NEW)
FURTHER MATHEMATICS
AS/Advanced

SUMMER 2019

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FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2019

Advanced Subsidiary/Advanced

FURTHER PURE MATHEMATICS A - AS UNIT 1

General Comments

The candidates performed very well on a high number of occasions and there were some excellent scripts. Many candidates began well, before struggling with some elements of the middle section of the paper, but then successfully earned marks towards the end of the paper.

Comments on individual questions/sections

Q.1 This question was answered well by many candidates. There was little difference in the numbers of candidates using the inverse matrix method and those using simultaneous equations. However, more than a few candidates using the inverse matrix method multiplied the matrices in the wrong order, resulting in a possible maximum of only 3 marks.

Q.2 This question was also answered well by the majority of candidates. However, poor notation resulted in the deduction of marks for numerous candidates. This poor notation mainly involved the omission of "$\mathbf{r} =$" at the beginning of the vector equation, or multiplying both direction vectors by the same coefficient. Some candidates found correct direction vectors, but did not write full vector equations. In part (*b*), whilst the majority of candidates knew the correct method to use, some candidates used the full vector equations to find points of intersection, making no comment on perpendicularity.

Q.3 Candidates did not perform as well as expected on this question. Whilst many candidates found z correctly, few candidates found w correctly. Many candidates plotted z on an Argand diagram, but many also believed that w was a reflection in the real axis. In part (*b*), many candidates gained follow-through marks and the majority used the rationalising surds method. However, those using the rules of modulus and argument for dividing complex numbers were almost always awarded full marks.

Q.4 Questions on proof by induction have appeared in the legacy qualification and also in the Summer 2018 Unit 1 paper, so it was disappointing that rarely were full marks awarded for this question. Many candidates were aware of the steps involved in mathematical induction, but it seemed they were unaware of the subtlety of some of the steps and were simply repeating taught processes. Candidates needed to include the element of doubt e.g. "Assume it is true for $n = k$", followed by a conclusion detailing "If it is true for $n = k$..."

Q.5 The vast majority of candidates followed Method 1 in the mark scheme, realising that a quadratic factor could be derived. Some candidates did not multiply through by 2 to remove fractions and consequently encountered more problems. Poor algebraic manipulation sometimes resulted in candidates arriving at the incorrect quadratic equation to solve, whilst others substituted values incorrectly into the quadratic formula. It was disappointing to see some candidates reaching the conclusion that the quadratic equation had no roots, rather than solving for complex roots. Some candidates used the roots-of-polynomials method and were generally successful in reaching a quadratic equation, but similar errors occurred to those seen in the factorising method.

Q.6 This question was answered very well by the majority of candidates. However, some candidates were unable to substitute $x + \mathrm{i}y$ correctly, or square correctly after substitution, leading to errors.

Q.7 In part (*a*), many candidates were able to square the expression and gain the first mark. Most candidates were able to substitute expressions for $\sum r^2$ and $\sum 4r$, but only some were able to substitute an expression for $\sum 4$. Fewer candidates were able to deal with the $2m$ in the limit, but those who realised, and substituted subsequently, were able to gain full marks. In part (*b*), few candidates heeded the 'hence' and simply calculated the sum of 13^2 to 22^2. On other occasions, candidates did not take note of the lower limit of 11, and whilst they calculated $\sum_{r=1}^{20}(r+2)^2$ correctly, no marks could be awarded.

Q.8 This was the most poorly-answered question on the paper. Often, candidates seemed to state various vectors without a clear idea of the direction in which their solution was heading. Some candidates had elements of both methods detailed in the mark scheme; however, their workings were often left incomplete.

Q.9 Although part (*a*) was very well-answered, some candidates were unable to square $x + \mathrm{i}y$ correctly, whilst other candidates did not take account of the '-1'. Part (*b*) often began well, with the majority of candidates finding expressions for u and v correctly; however, when eliminating x or y from their expressions, they often encountered difficulties.

Q.10 The majority of candidates were able to begin the question by stating expressions for the sum of roots and the product of roots of the quadratic equation given in the question. However, some had sign errors in their initial equations, which often made the question more difficult. The majority of candidates were able to find expressions for the sum of roots and the product of roots of the cubic equation; however, many errors were encountered with the sum of pairs of products of roots. Fewer candidates than expected were able to spot $\alpha\beta + \alpha(\alpha+\beta) + \beta(\alpha+\beta) = \alpha\beta + (\alpha+\beta)^2$. Furthermore, when forming the cubic equation, candidates often substituted their new expressions with sign errors, and '= 0' was often missing.

Summary of key points

- Most candidates worked through the paper in question number order. Candidates are reminded that this is not essential and working to their strengths may lead to higher marks.

- Poor algebraic skills were apparent in many questions, particularly on squaring expressions and using the correct form for equations (such as vector equations).

- Problem-solving skills were not always apparent, leading candidates to omitting some parts of questions.

- Not all candidates made good use of the Formula Booklet – candidates are reminded of the assistance provided within the Formula Booklet.

- Most candidates showed all their working; however, all candidates are reminded to show sufficient working for their solutions.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2019

Advanced Subsidiary/Advanced

FURTHER STATISTICS A - AS UNIT 2

General Comments

The new specification continues to give a wide spread in attainment over the course of the paper. Candidates were, once again, generally very good at performing calculations using formulae in the Formula Booklet; for example, calculating Spearman's rank correlation coefficient and the equation of a regression line. Compared to last year's examination, many more candidates were able to produce appropriate hypotheses when required to. As expected, the questions which required interpretation in context were the least well answered. The question on the, previously unfamiliar, exponential distribution proved challenging.

Comments on individual questions/sections

Q.1 As stated above, the calculation for Spearman's rank correlation coefficient was successfully carried out by all but the weakest of candidates. Although the scatter diagram in part (*a*) was conceptually understood by many candidates, many simply drew a scatter diagram showing positive correlation. In part (*c*), the question was designed to demonstrate that, despite the small positive correlation, the judges disagree strongly on most of the cheeses and that one should never simply use the product moment correlation coefficient to come to any conclusion without reference to a scatter diagram. Despite the suggestion to sketch a scatter diagram, many candidates did not and therefore failed to realise the nuance of the extent of agreement and disagreement by the judges.

Q.2 This question had a familiar feel to previous questions on this topic, but with the added challenge of identifying the binomial distributions. This challenge proved a step too far for several candidates who were unable to calculate p. This led to some difficulty in the calculation of $\mathrm{Var}(XY)$. Despite this challenge, this was the second most accessible question on the paper and many candidates scored full marks.

Q.3 Candidates, on the whole, answered part (*a*) very well indeed. Part (*b*) was also well answered, with only some candidates misunderstanding which probability should be multiplied by 3. Disappointingly, however, part (*c*) was not answered at all well. Candidates seemed almost completely unprepared to tackle a question on the exponential distribution, with the vast majority of candidates having no idea how to start this part of the question.

Q.4 Although questions on this topic, continuous random variables, have appeared in the legacy specification papers, the probability density functions tended not to be piecewise. Despite this, most candidates coped well with the piecewise function and answered this question very well. However, many lost the final accuracy mark due to premature approximation. Unfortunately, some candidates were unable to access the question because they seemed unsure about how to answer questions where the probability distribution function was piecewise.

Q.5 Part (*a*) was not as well answered as part (*b*). Of the candidates that understood the hypothesis that Chris was testing, all but a small fraction were able to look at the data and conclude that there is a tendency for NHL players to have a birthday earlier in the year. Most candidates who attempted a conclusion simply stated "not uniformly distributed". Although part (*b*) was well answered, some common errors included combining the groups into 3-month intervals despite the expected frequencies all being above 5, and not stating hypotheses which are part of a hypothesis test.

Q.6 Similar to last year's question on linear regression, this was by far the best answered question on the paper, with a vast majority of candidates getting full marks in part (*b*). In part (*a*), the most common error was stating the limitations of the regression line in general terms, rather than in the context of this question with reference to the scatter diagram in the question.

Q.7 The routine calculations in parts (*a*) and (*b*) were well answered. Once again, candidates were required to consider the data in the question and to interpret it in context in order to earn the relevant marks in part (*c*). A common incorrect answer was "Ankle because 57.9551 is the biggest number". Although many candidates were able to correctly identify Hand/Fingers, few candidates were able to put this into context, with reference to the low involvement of hands in football and the high involvement of hands and fingers in basketball.

Summary of key points

- It was encouraging to see good responses to familiar questions.
- Candidates should be encouraged to engage with the data in addition to following routine calculations.
- Forming the correct hypotheses is part of a hypothesis test and candidates should be familiar with the different hypotheses that are associated with the different tests.
- Candidates should be prepared to answer questions on the exponential distribution.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2019

Advanced Subsidiary/Advanced

FURTHER MECHANICS A - AS UNIT 3

General Comments

This summer's paper turned out to be more accessible than the Summer 2018 paper. The paper allowed candidates of all abilities to display their knowledge and demonstrate their mathematical skills. It was apparent that there was sufficient time to complete the paper.

Notably, question 3 and question 7 were the most demanding questions on the paper, whilst question 4 was by far the most successful. Many high scoring scripts with exemplar responses were seen.

Comments on individual questions/sections

Q.1 This question provided a gentle start to the paper. Almost all candidates used Hooke's law in part (*a*) and then applied conservation of energy in part (*b*). However, a significant proportion of candidates did not interpret this question correctly, as the compressed length of $\frac{2}{5}\times 0\cdot 15 = 0\cdot 06$ was used instead of $\frac{3}{5}\times 0\cdot 15 = 0\cdot 09$, the actual compression of the spring. Thus, incorrect answers of $\lambda = 52\cdot 5$ and $v = 3\cdot 6$ were frequently seen. Fortunately, only two marks were lost due to this error.

It was encouraging to see the most able candidates working algebraically with $x = \frac{3}{5}l$.

Q.2 Part (*a*) was generally well answered, with only occasional sign errors occurring.

In parts (*b*) and (*c*), almost all candidates were aware of how to calculate the dot product of two vectors, but solutions often involved careless errors. Again, there were frequent sign errors and some candidates did not recognise that $\left(\mathrm{e}^{-t}\right)^2 = \mathrm{e}^{-2t}$. More seriously, many candidates lost marks by failing to remove the unit vectors $\mathbf{i}$, $\mathbf{j}$ and $\mathbf{k}$, e.g.

$$\mathbf{F}.\mathbf{v} = 9t^3\mathbf{i} + 32t\mathbf{j} - 2e^{-2t}\mathbf{k} \qquad \text{and} \qquad \mathrm{KE} = \frac{9}{4}t^4\mathbf{i} + 16t^2\mathbf{j} + e^{-2t}\mathbf{k}\ .$$

Part (*d*) was only successfully answered well by the most able candidates.

Q.3 Overall, this was the second most challenging question on the paper. Nevertheless, parts (*a*) and (*b*) were very well answered. For a small number of candidates, misconceptions from question 2 were mirrored here by candidates incorrectly writing AB^2 as

$$AB^2 = (2-8t)^2 \mathbf{i} + (-2+8t)^2 \mathbf{j} + (-1+4t)^2 \mathbf{k} .$$

Only the most able candidates managed to achieve full marks in part (*c*). The most common errors were incorrectly writing the quadratic equation as one of the following:

- $144t^2 - 72t + 9 = 600^2$
- $144t^2 - 72t + 9 = 600$
- $144t^2 - 72t + 9 = 0 \cdot 6$

Unfortunately, many able candidates lost the final mark as they failed to interpret their solutions to the problem in their original context (AO3) and simply wrote $t = 0 \cdot 2$ hours instead of 9.12 a.m.

Q.4 This was the most successful question on the paper. Almost all candidates scored full marks on parts (*a*) and (*c*). Part (*b*) was reasonably well done, with the most common error being the omission of either the component of weight down the slope, or, more often, the resistance of 2000 N in the Newton second law equation.

Q.5 As expected, most candidates recognised that the tension needed to be resolved vertically and hence scored full marks in part (*a*).

Part (*b*) was less successful as some candidates decided to stop once they had determined the radius of the horizontal circle. Disappointingly, some prematurely rounded the value of the radius, thus leading to an accuracy error in the length of each chain. Nevertheless, many exemplar solutions were seen in which candidates recognised the independence of θ and moved straight to $l = 5 \cdot 77$ without evaluating the radius.

Q.6 It was reassuring to see that candidates were not troubled by the context of this question. Parts (*a*) and (*b*) were generally done well. Errors in part (*a*) were made in attempting to establish the potential energy component(s) for the energy equation. Many of these errors can be attributed to candidates not drawing a clear diagram and/or not making their point of reference clear enough.

Unfortunately, within parts (*a*) and (*b*), sign errors were often seen when rearranging equations, with many having to ‘tinker’ with their solution to try to convince examiners of the printed result for R.

In part (*c*), the most favoured method was to take $\theta = 180$ in the given expression for R in order to show that $R = mg > 0$. Surprisingly, very few decided to test for $R = 0$.

In part (*d*), very few candidates considered the loss in potential energy for use with the work-energy principle, instead opting for the slightly less efficient approach using kinetic energy.

Q.7 Overall, this was the least successful question on the paper with very few candidates managing to achieve full marks. However, part (*a*) was extremely well answered, demonstrating that candidates have a strong understanding of momentum and restitution, even in an algebraic setting. Candidates who used the ratio method to find e, the coefficient of restitution, were less successful as sign errors were much more common.

Many candidates were unable to secure the final mark in part (*b*) since the fact that $e = \frac{1}{2}$ was not initially used. As a result, the required loss in KE was often attempted in terms of e, thus giving terms such as $(1-e)^2$ and $(1+e)^2$.

The majority of candidates who attempted part (*c*) decided to replicate their argument from part (*a*). Given that only 3 marks were available, part (*c*) was designed to assess AO2 in providing the opportunity for candidates to deduce that

$$\text{Velocity of } B \text{ after } 2^{\text{nd}} \text{ collision } = \frac{1}{2}(1-e_1)\times\frac{3}{4}u,$$

using their answer from part (*a*), $v_A = \frac{1}{2}(1-e)u$, with e replaced with e_1 and u replaced with $\frac{3}{4}u$. Thus, candidates wasted valuable examination time as further calculation was not required.

Summary of key points

- The most successful candidates drew clear diagrams to help them interpret the questions.
- Marks continue to be lost due to premature approximation. Candidates should be encouraged to use as much accuracy as possible, thus taking advantage of the exact form often produced by the calculator.
- Many candidates did not consider the number of marks available for some questions and hence provided unnecessary work. This would be worth developing as good examination technique.
- Some candidates still believe that vector questions must always result in a vector answer.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2019

Advanced Subsidiary/Advanced

FURTHER PURE MATHEMATICS B – A2 UNIT 4

General Comments

The candidates performed very well on a high number of occasions and there were some excellent scripts. However, some candidates encountered difficulties with the requirements of some questions and poor algebraic skills were often seen, leading to low marks being awarded in these questions.

Comments on individual questions/sections

Q.1 Many candidates answered part (*a*) well. Whilst part (*b*)(i) began well, with the majority of candidates finding the cube roots, few candidates stated their roots as coordinates, thereby losing the final mark. It was disappointing to see 'isosceles' appear more often than 'equilateral' as the name of the triangle formed by the cube roots, with some candidates attempting to find the length between vertices to support their answer.

Q.2 Part (*a*) was answered well by many candidates, although some candidates did not show all their working. When results are given in the question, candidates are reminded to show sufficient working to 'convince' the examiner, as noted in the mark scheme. Part (*b*) often began well, although some candidates did not show their working for solving the quadratic equation. Some candidates doubled their value of x before using the general form, losing the final mark.

Q.3 In part (*a*), the majority of candidates used the determinant method for determining whether a set of equations has a unique solution. Those who used this method usually gained full marks. Those candidates who used the echelon form method sometimes failed to give a sufficiently detailed statement to gain the final mark. In part (*b*), Method 3 (inverse matrix method) proved to be the most popular, and this method was very successful. Those candidates who used the other two methods often ran into algebraic manipulation errors, leading to a loss of accuracy marks.

Q.4 In part (*a*), candidates often began well and accuracy marks were awarded for each of the steps, irrespective of the order in which they were completed. However, some candidates were unable to make the connection between $\operatorname{cosec}^2 y$ and $\cot y$. Part (*b*) was very well answered. Part (*c*) was also well answered, although some candidates were unable to see the connection between parts (*b*) and (*c*); some began again, with all marks available to them, whilst other candidates integrated part (*b*), losing the M1A1 marks at the beginning. In part (*c*), many candidates did not write the logarithmic term with modulus signs and, whilst they were not penalised this time, it often led to an incorrect statement in part (*d*). Few candidates were able to spot that the integrand was undefined at $x = -1\cdot5$, focusing more often on the fact that substituting $x = -1\cdot5$ would lead to a negative value inside the logarithm.

Q.5 In part (*a*), many candidates were able to use the factor formula; however, not all candidates were able to express $\sin(-\theta)$ as $-\sin\theta$. Part (*b*) was answered well, with the majority of candidates gaining full marks, benefitting from the permitted follow through from part (*a*), where appropriate.

Q.6 This question proved to be the highlight of this paper, with the vast majority of candidates answering it very well. Some candidates failed to write their final answer as an equation and consequently lost the final A1 mark.

Q.7 In part (*a*), the majority of candidates were able to use the expansion of $\ln(1+x)$ from the Formula Booklet, although some squared $(-x)$ incorrectly for the second term. However, some candidates worked from the Maclaurin expansion of $f(x)$. In part (*b*), many candidates were able to use the rules of logarithms, but few candidates were able to correctly deal with the power of -2, losing accuracy marks. Some candidates again worked with the Maclaurin expansion of $f(x)$, and differentiation errors proved costly on numerous occasions.

Q.8 This question was answered well by many candidates. The first four marks in part (*a*) were usually awarded, as were the final two A2 marks for finding θ and r, particularly because of the follow through allowed from candidates' trigonometric equation. The double angle formulae for $\tan(2\theta)$ and $\cos(2\theta)$ were used in equal measure by candidates. In part (*b*), candidates sometimes struggled to convert to Cartesian coordinates from polar form.

Q.9 In part (*a*), more candidates used Method 2 (implicit differentiation) and this often proved very successful. Those candidates who used Method 1 (chain rule) often omitted the negative sign, leading to an answer of 1 rather than -1. In part (*b*), candidates often omitted the '$\times 4$' in the first term, which led to a loss of two accuracy marks. In part (*c*), candidates again omitted the '-1' when using the chain rule, but benefitted from the permitted follow through for the B1 marks at the end of the question. Disappointingly, some candidates thought $\tanh^{-1}(1-x)$ was equivalent to $\dfrac{1}{\tanh(1-x)}$.

Q.10 This question was answered well on numerous occasions. Those candidates who divided by $\sec x$ often continued to gain full marks, although some encountered difficulties in simplifying $\dfrac{\operatorname{cosec} x}{\sec x}$. Disappointingly, some candidates tried to use $e^{\int \operatorname{cosec} x \, dx}$ as the integrating factor, gaining no marks.

Q.11 Part (*a*) was very well answered, with candidates showing their workings to gain full credit. In part (*b*), candidates often set up the integrand correctly, but encountered difficulties dealing with $\cosh^2(2x)$. Some of these candidates made use of the exponential form and, whilst this was a longer method than intended, it often led to a correct answer. Part (*c*) was very well-answered, with the majority of candidates spotting that it was double their answer to part (*b*); some candidates gave symmetry as a reason and, whilst it was not necessary, it was pleasing to see.

Q.12 Parts (*a*) and (*b*) were answered well by the majority of candidates, with only a few candidates not rounding to three decimal places in part (*a*). In part (*b*), the majority of candidates used Method 2 in the mark scheme, including converting to decimal form. Those candidates who used the full calculator output, reached the correct conclusion. Candidates are reminded that using exact values is to be expected in Further Pure Mathematics papers. In part (*c*), there was an even spread of candidates using each of the three methods in the mark scheme. There was good algebraic manipulation to be seen, with candidates stating each required step to 'convince' the examiner, as the result was given in the question. However, some candidates were unable to deal with squaring the exponential forms of $\cosh x$ and $\sinh x$, with the '$+\frac{1}{2}$' often omitted.

Summary of key points

- Most candidates worked through the paper in question number order. Candidates are reminded that this is not essential and working to their strengths may lead to higher marks.

- Poor algebraic skills were apparent in many questions, particularly when differentiating using the chain rule.

- Problem-solving skills were not always apparent, leading candidates to omitting some parts of questions.

- Not all candidates made good use of the Formula Booklet – candidates are reminded of the assistance provided within the Formula Booklet.

- Most candidates showed all their working; however, all candidates are reminded to show sufficient working for their solutions. Particular attention to detail is required when the candidate is asked to show a given result.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2019

Advanced Subsidiary/Advanced

FURTHER STATISTICS B – A2 UNIT 5

General Comments

The standard for the first assessment of the GCE Further Mathematics A2 Unit 5 was very high. Candidates were able to demonstrate their knowledge and mathematical ability very well, with many scoring close to full marks. Candidates coped very well indeed with the demands of the new content, such as the non-parametric tests. However, there were some candidates that were out of their depth at this level. Some of the challenges included identifying the t-distribution and finding the confidence level for a confidence interval.

Comments on individual questions/sections

Q.1 Although this question was generally well answered, there were a significant proportion of candidates that failed to identify the need to use the t-distribution. There was also a large number of candidates who thought that the Central Limit Theorem was used.

Q.2 Part (*a*) was generally well done. This question did prove to be accessible to many candidates, with a considerable number able to score full marks. Unfortunately, there were also a few candidates who were unable to answer part (*b*) at all. A common error was to divide $\mathrm{E}(X)$ by 9 to find $\mathrm{E}\left(\bar{X}\right)$.

Q.3 This was another question that was generally very well answered. Part (*a*) was far less successful than part (*b*), with many candidates unable to commence the question. Part (*b*) was a familiar question and very well answered indeed.

Q.4 This question was the most poorly answered question on the paper. The vast majority of candidates were able to make a start on finding the confidence interval in part (*a*). Most were able to continue to find the correct confidence interval, although some misunderstood the mean weight gain as the total weight gain and therefore divided 900 by 12 and 870 by 10. Of the candidates that were able to calculate the confidence interval, only a few were able to interpret the interval correctly. An extremely common incorrect answer was stating that protein powder A was better than protein powder B because most of the interval was positive. Part (*c*) was very poorly attempted. Of the few candidates that knew that they had to form an inequality in terms of k and set it greater than 0, some failed to double the calculated value before subtracting it from 100%. Several sensible answers were given for part (*d*).

Q.5 This was the most successfully answered question on the paper, despite the fact that many candidates found explaining the appropriateness of a Wilcoxon signed rank test challenging. Another common error was the omission of the word ‘average’ in the hypotheses. Some candidates seemed extremely well versed in answering a question on this topic.

Q.6 The required thought and insight in part (*a*) was lacking for the most part. Some candidates simply stated “Hopcyn wants to see if it’s less than 123. The company wants to see if it’s less or more.” A more considered, in depth answer was required. Candidates made a number of different errors in part (*b*). Some made errors calculating s^2, whereas others made errors calculating the *p*-value. However, many candidates were able to produce fully correct solutions.

Q.7 This was an extremely well answered question. The only errors that appeared with any regularity were the omission of the word ‘median’ or ‘on average’ and stating the critical region as $U > 48$ or $U < 8$.

Q.8 This question offered candidates several opportunities to recover from any previous loss of marks, with the inclusion of several part questions which asked candidates to show various results. As a result, there were many fully correct solutions seen for this question. The most challenging parts were parts (*c*) and (*d*). Candidates that did not recognise the binomial distribution with the correct parameters found the subsequent parts of the question very difficult.

Summary of key points

- It was encouraging to see so many scripts of a very high standard.

- Candidates were able to go through the processes required for non-parametric tests well, but should be more familiar with why they are used and the conditions required in order to carry out the tests.

- Candidates are encouraged to give more thought and consideration to the explanations they give, to ensure they are linguistically coherent and as insightful as possible.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2019

Advanced Subsidiary/Advanced

FURTHER MECHANICS B – A2 UNIT 6

General Comments

This is the first assessment of this unit in the reformed specification and so it was reassuring to see that it was well received by most candidates. It also differentiated between candidates of all abilities. Many high scoring scripts were seen and this unit was a pleasure to mark. There was no evidence to suggest that candidates found the paper too long to complete in the allocated time, as most candidates managed to attempt all the questions on the paper.

Interestingly, the three least accessible questions on the paper, questions 2, 4 and 5, covered content new to the specification.

Comments on individual questions/sections

Q.1 This was by far the most successful question on the paper with only occasional sign errors occurring. Some of these sign errors were due to candidates electing to use the substitution $u = 9000 - v^2$ instead of $\int \frac{f'(v)}{f(v)} \mathrm{d}v$.

Part (*d*) often prevented candidates from obtaining full marks as many did not deduce that $v = 30\sqrt{10}$ was a limiting value.

Q.2 Candidates were aware of the required approach for this type of question, with almost all arriving at a centre of mass for part (*a*). Unfortunately, a small number of candidates failed to include the particle at Y in their calculations.

For the area of the lamina, a variety of methods were seen. Some candidates made the decision to sum two rectangles and a triangle. This approach turned out to be much less rewarding than the more efficient method of subtracting a triangle from a rectangle.

The majority of errors were made in the calculation of at least one of the coordinates for the centre of mass of the semi-circle. The value $5 + \frac{32}{\pi}$ was frequently seen since candidates worked relative to the point X instead of the vertex Y.

The most successful candidates constructed one table for both $\bar{x}$ and $\bar{y}$.

It was gratifying to see that almost all candidates correctly identified the correct triangle required in part (*b*), irrespective of any misconceptions in part (*a*).

Q.3 Despite the purely algebraic setting, this question was very successful overall.

For part (*b*)(i) a small number of candidates incorrectly wrote

$$T = \frac{14(e+x)}{l} - mg \, .$$

Fortunately, many of these went on to correctly answer part (ii). In part (iii), many candidates were able to state the maximum extension as e, but, disappointingly, some of these were unable support it with a convincing reason.

Part (*c*) did not pose any problems, often allowing those who struggled with the earlier parts to secure six marks.

Q.4 Almost all candidates answered part (*a*) correctly. Some candidates dealt with the $\mathbf{i}$ and $\mathbf{j}$ components in separate equations.

Part (*b*) was less successful. Restitution was often erroneously applied to the whole vector as shown below,

$$\mathbf{v} = -\frac{5}{7} \times (-3\mathbf{i} + 7\mathbf{j}) = \frac{15}{7}\mathbf{i} - 5\mathbf{j} \, .$$

Consequently, some candidates had to deal with a much more demanding impulse equation in part (*c*).

Most of the correct responses in part (*d*) used $\text{time} = \dfrac{\text{distance}}{\text{speed}}$ to get $t = 0 \cdot 35$.
However, a significant proportion using this method then failed to add $1 \cdot 75$ to their final answer.

It was encouraging to see that the vast majority of candidates were able to successfully answer part (*e*). This demonstrated familiarity with Assessment Objective 3 (AO3) which assesses the ability to recognise the limitations of models and to explain how to refine them.

Q.5 This was by far the least accessible question on the paper. In part (*a*), many candidates needlessly derived the equation for the volume of a hemisphere, thus wasting valuable examination time. This was disappointing since there is a similar question in the GCE Further Mathematics Sample Assessment Materials, in the A2 Unit 6 paper. Furthermore, some responses were ambiguous as it was not clear if the π's had been cancelled, e.g.

$$\bar{x} = \frac{\int_0^r xy^2 \, \mathrm{d}x}{\frac{2}{3} r^3} \, .$$

In part (*b*), the least effective solutions did not involve constructing a table including the mass of the solids, together with the corresponding centre-of-mass distances from a fixed point. In a small number of responses, the hemisphere and cylinder were treated as though they had equal density. Also, for the distance of the centre of mass of the hemisphere from the plane face base of the composite solid, some candidates simply wrote $\frac{3r}{8}$ and forgot to add $2r$.

Q.6 Candidates demonstrated a very strong understanding of how to resolve forces. As a result, this was the second most successful question on the paper. The fact that this question was set purely algebraically rarely posed a problem.

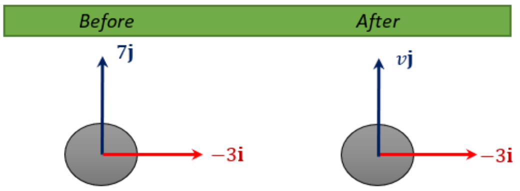
In part (*a*), a small number of candidates chose to take moments about the point A. As expected, due to the additional terms, this method was slightly less successful.

In general, the frictional force from part (*a*) was effectively used in part (*b*), with the correct value of $x=5$, with the main error being attributed to using $\tan\theta=\frac{1}{4}$ instead of $\tan\theta=4$.

Summary of key points

- Many candidates did not know that the law of restitution need only be applied along the line of impulses. Furthermore, if restitution calculations are needed, the line joining the centres of the spheres will always be parallel to either $\mathbf{i}$ or $\mathbf{j}$.

- The most successful candidates drew clear diagrams and constructed tables, where appropriate, to help them interpret the information in the questions, e.g. in question 4,



- Many candidates did not identify that $\ln\left|\frac{9000}{9000-v^2}\right|$ is undefined at $v=30\sqrt{10}$, i.e. $v=30\sqrt{10}$ is a limiting value of $v(x)$.

- Marks continue to be lost due to premature approximation. Candidates should be encouraged to use as much accuracy as possible, thus taking advantage of the exact form often produced by the calculator.

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