GCE EXAMINERS' REPORTS

GCE (NEW)
FURTHER MATHEMATICS
AS/Advanced

SUMMER 2022

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FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2022

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. However, poor algebraic skills were apparent throughout the performance range. There was little pattern in the scripts as to the comparative ease of questions.

Comments on individual questions/sections

Q.1 Part (a) was answered well by many candidates, with the majority deciding to multiply the complex numbers before finding the modulus and argument. Part (b) was answered far poorer than expected. Many candidates found $\frac{1}{v}$ correctly and then their answer for v appeared without any workings being shown. Some candidates rationalised their $\frac{1}{v}$ before finding v, only to have to rationalise again. However, this was the best-answered question of the paper.

Q.2 Part (a) was answered well by many candidates. The majority of candidates used the inverse method rather than solving simultaneous equations. Part (b)(i) was very poorly answered – a typical response was doubling the values in the matrix for a reflection in the line $y = -x$. A full follow-through was offered for part (b)(ii) and many candidates were able to obtain these marks, although some candidates were unable to find a midpoint of their coordinates, which was disappointing as this skill comes from GCE Mathematics Unit 1.

Q.3 This question was answered very well by the majority of candidates, with a large number gaining full marks. Some candidates failed to write their answer as the required Cartesian coordinates, but only lost the final accuracy mark. However, some candidates tried to find the Cartesian equation of the line, or only used the direction vector element to substitute for x, y, z.

Q.4 This was the most poorly answered question on the paper and was answered in one of three ways by candidates. Some believed this to be a proof by induction question and gained 0 marks. Some expanded the $(3N-2)^2$ and used the formulae for sums of series; depending on how they began their answer, some credit might have been given. For those who spotted that the left-hand side needed replacing by $\sum r^2$, the first two marks were gained well. Following this, many candidates failed to show sufficient working to gain full credit, often going from a cubic equation with non-integer coefficients to the solution. Of those who found the three solutions, the vast majority did not reject $N = \frac{1}{2}$, so lost the final accuracy mark.

Q.5 This was the second best answered question on the paper. The majority of candidates scored full marks in part (a), with only poor algebraic errors leading to marks being lost. However, in part (b), candidates often gave geometric descriptions of their equation in (a), rather than an interpretation of the locus of *P* referring back to (a).

Q.6 This was the most difficult question on the paper for many candidates. However, many candidates gained some marks for writing down values for the sum of roots, the sum of pairs of products, and the product of all the roots. Some candidates showed an understanding of the common ratio to gain further credit. However, of those candidates who progressed further, many failed to appreciate the two solutions from $\alpha^2 = 3$ and therefore lost some accuracy marks.

Q.7 Part (a) was answered very well. In part (b), many candidates were able to find the dot product and the product of moduli. However, whilst many candidates found the obtuse angle, they believed that subtracting 90^o from their answer would lead to the acute angle.

Q.8 Many candidates started answering this question well. They used the information from the Formula Booklet to set up a matrix equation and multiplied it out correctly. However, some candidates did not equate their expressions for the resulting x and y coordinates and so gained no further credit. For those who reached an equation for y in terms of x, many failed to show sufficient working to rationalise their surd fraction, losing the final two marks.

Q.9 This question was answered more poorly than expected. In part (a), poor algebraic skills often lead to candidates making errors in dealing with the three fractions correctly, particularly subtracting a fraction. In part (b), most candidates realised the connection with part (a) and began by substituting values into r. However, errors in cancelling out the fractions were frequent and some candidates failed to obtain the required remaining fractions for simplification. In part (c), a variety of different answers were seen – many candidates found 25/168 and 25/156, but many candidates encountered difficulties in simplifying this to a ratio.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2022

Advanced Subsidiary/Advanced

FURTHER STATISTICS A – A2 UNIT 2

General Comments

This proved to be an accessible paper, with many candidates scoring very well indeed. Candidates were, once again, generally very good at performing routine calculations and tests, such as the chi-squared test and finding $F(r)$. These AS Further Mathematics candidates demonstrated good exam technique, although running out of time may have contributed to the lower than expected score for question 7. As is often the case, the questions which required interpretation in context were the least well answered. The question on the exponential distribution, once again, proved challenging.

Comments on individual questions/sections

Q.1 Question 1 was fairly routine and was the most well-answered question on the paper. The biggest difficulty was in part (c)(i), where candidates did not appreciate the mathematical nature of the question. The mathematical answer is, of course, 1p more than E(X), but many candidates gave answers such as £2.00, possibly because it was a round number.

Q.2 Parts (a) and (b) were both routine processes which were generally well-answered, with part (a) being the better of the two, as one would expect. Part (c) was not as well-answered with fewer candidates able to express themselves well enough to score any marks. The answers "yes" or "no" were accepted in part (c), providing they were followed by a correct supporting statement. Most candidates opted for "No, because Spain is a different country and might have a different relationship between rate of unemployment and wage inflation than the UK."

Fewer than 10% of candidates were able to give the assumption of the underlying data being bivariate normal as the correct answer in part (d).

Q.3 Question 3 proved to be the most challenging question on the paper. Many candidates knew that the means should be multiplied by 4 to get the average rate for the whole game, but not as many knew that they could simply add the two values for Steff and Klay together. Some candidates tried every possible combination of Steff and Klay's baskets to make 20. This did work and, on the rare occasion, a candidate using this method arrived at the correct answer, but, more often than not, it lead to chaos. The exponential distribution proved difficult once again. In part (b), it was common for candidates to omit the '$\times 12$' and end up with $\frac{1}{2.1}$ minutes. Had candidates stated quarters instead of minutes, that, of course, would have been acceptable. The distribution was not often stated, implying that the candidates did not know that waiting time in a Poisson process can be modelled with the exponential distribution. Only a minority of candidates seemed to know that the mean and standard deviation were equal.

Q.4 Overall, this question was generally well done. Part (b)(i) in particular was very well done indeed. The difficulties came in parts (a) and (b)(ii). Explanations in part (a) were often vague and did not explain sufficiently why $b \geq 4$. Many understood the notion of probabilities not being negative, and probability density functions not being negative, but were unable to sufficiently link the two and got bogged down in r being ≤ 4 and showing that to be the case.

In part (b)(ii), the most common error was omitting the limits (or omitting the $+c$). This lead to an expression for $F(r)$ that did not include $-\frac{5}{27}$. This, of course, did not matter in part (iii) because the $-\frac{5}{27}$ terms cancel.

Q.5 Question 5 was unfamiliar, and this was evident, as this was the second most poorly answered question on the paper. Many candidates used a uniform distribution, which does not account for the throwing of multiple dice.

Q.6 This was the second best answered question on the paper. The chi-squared test for independence is a familiar question and fairly routine. Part (e) was the most challenging part. The common error of comparing the *p*-value with the chi-squared contributions value was prevalent again this year.

Q.7 Question 7 was a fairly routine question with many candidates scoring 5 out of 7 marks. One mark was withheld for premature approximation, where the rounded figures were used. Despite the accessibility of the question, more than 10% of candidates did not attempt the question which points to a lack of time towards the end of the exam. In part (b), it was common to see one of the two comparisons required, but sadly, not both.

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.
- Candidates should be prepared to calculate $F(x)$ in cases where the range of values for x does not start at 0, or is in more than one part.
- Candidates should be prepared to answer questions on the exponential distribution.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2022

Advanced Subsidiary/Advanced

FURTHER MECHANICS A - AS UNIT 3

General Comments

The paper allowed candidates of all abilities to display their knowledge and demonstrate their skills. It was apparent that there was sufficient time to complete the paper. Excluding question 7, this turned out to be of a similar accessibility to that of the Summer 2019 paper. Question 7 was the most demanding question on the paper with a low facility factor of $39 \cdot 3$, whilst question 2 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 and, as expected, it was answered successfully by the majority of candidates. Notably, many solutions to part (b) used the calculated value of the angular velocity from part (a), despite the fact that the linear speed was given in the question.

Q.2 This was the most successful question on the paper. Almost all candidates scored full marks on part (a). In part (b), the majority used the conservation of energy as instructed and they also realised that the value for the kinetic energy at the top of the platform could be inherited from part (a). A small number of candidates elected to use $v^2 = u^2 + 2as$ with $u = \pm 7.8$, $a = g$ and $s = 10$, which lead to a correct final result. However, this method gained no credit since the direction of projection was not provided and this method assumes a rectilinear path in the vertical plane.

Many candidates went straight to mathematical results without providing a supporting statement. For example, only a handful of candidates wrote something similar to the statements below,

Using the Conservation of Energy

Total energy at start (platform) = Total energy at end (water)

Part (c) of the question, on the work-energy principle, proved to be accessible to all, as the required speeds of 13 and 16 were provided to candidates. There was no penalty for using 16 instead of $\sqrt{\frac{6421}{25}}$.

Q.3 Almost all candidates were adept at tackling this style of 'collision' question. Furthermore, the use of algebraic quantities for the mass of each sphere did not pose a problem. Consequently, parts (a) and (b) were generally completed to a high standard, with only careless sign errors causing issues. The most frequently seen error was to assume that *A* and *B* were moving in the same direction before the collision. However, since the speed of B after the collision was provided, candidates were generally able to rectify any initial misconceptions. Disappointedly, very few provided helpful signposting such as 'Using Conservation of Momentum' and 'Using Restitution'.

Most candidates were familiar with the meaning of impulse, with a small number using poor, but condonable, notation. For example,

Change in momentum $= 36$

$(4m)(1.5-9) = 36$

$-m = 1.2 \quad \therefore \quad m = 1.2$

It was encouraging to see that many candidates appreciated the significance of 'equal radii' in successfully answering part (d).

Q.4 Almost all candidates scored full marks in part (a). Part (b), which was less successful, provided a variety of attempted solutions. In (b)(i), the most successful candidates began by finding the vector $\mathbf{AB}$ and then were quickly able to deduce that $\mathbf{F_1} = \frac{3}{2}\mathbf{AB}$ or $\mathbf{AB} = \frac{2}{3}\mathbf{F_1}$, often by inspection. Many of these successfully calculated the dot product of $\mathbf{AB}$ and $\mathbf{F_1}$ in order to find the work done for (ii).

A much less succinct method was chosen by a significant number of candidates who tackled part (b)(i) by using $\mathbf{F_1}.\mathbf{AB} = |\mathbf{F_1}||\mathbf{AB}|\cos\theta$ and verifying that $\cos\theta = 1$. This approach meant that the work done in part (ii) had already been calculated, but not all candidates recognised this fact. For this particular approach, many considered the product of $|\mathbf{AB}|$ and $\mathbf{F_1}$ and hence concluded with an incorrect vector quantity for the work done. For example,

Work done $= 2\sqrt{29} \times (9\mathbf{i} + 6\mathbf{j} - 12\mathbf{k}) = \left(18\sqrt{29}\mathbf{i} + 12\sqrt{29}\mathbf{j} - 24\sqrt{29}\mathbf{k}\right)$

Q.5 Overall, attempts for this question were disappointing. Nevertheless, almost all candidates were aware that conservation of energy was required with 3 energy forms. Once again, very few provided clear signposting for their solutions and diagrams were often scrappy with no clear reference point. Incidentally, many candidates worked with the numerical value of g, before arriving at the printed result. Fortunately, as the expression for v^2 was given, candidates could progress irrespective of efforts in part (a).

Part (b) was very successful with the majority of candidates using the fact that $v = 0$ in the expression from part (a) to form and solve a quadratic equation with two solutions. Almost all candidates were able to interpret their solutions in their original context (AO3) and hence discard the negative value. Unfortunately, many used the formula method and made careless errors since they clearly did not check their solutions using their calculators.

A variety of successful solutions were seen for part (c), with methods such as Hooke's Law with $T = 2g$ and maximising v^2, with calculus being used in equal measure. Sadly, only a handful of candidates opted to complete the square which would have quickly revealed the desired results.

Q.6 It was promising to see that almost all candidates sketched an appropriate diagram and attempted to work parallel to the plane. In part (a), the most common error was incorrectly interpreting the meaning of 'deceleration is $0 \cdot 2\ \text{ms}^{-2}$', in that $0 \cdot 2$ was used in Newton's second law. Therefore, the incorrect answer of $P = 95\ 000\ (\text{W})$ was frequently seen.

Part (b) saw many successful fully correct solutions.

Q.7 Overall, this was the least successful question on the paper, with very few managing to achieve full marks. Many chose to ignore string BP and so dealt with a simple conical pendulum. Unfortunately, this approach gained no credit.

Supporting diagrams were rarely seen, as well as helpful signposting such as 'Using Newton's second law towards C' and 'Resolving vertically'.

Surprisingly for this unit, not all candidates were able to deduce that $\sin\alpha = 0.6$. Therefore, many candidates worked with $\alpha = \sin^{-1} 0.6$ and some candidates chose to evaluate $\alpha = 36.9^\circ$ to one decimal place, thus losing accuracy.

Part (c) was generally well answered, with 'follow through' marks being available for use of an incorrect ω from part (b).

Summary of key points

- The most successful candidates sketched clear diagrams to help them interpret the questions.

- In general, candidates are not using the full functionality of their calculators, e.g. for checking solutions of equations, exact/surd forms. Marks continue to be lost due to premature approximation and failure to check solutions of equations.

- Very few candidates provided helpful signposting such as 'Using Conservation of Momentum' and 'Using Restitution', instead preferring to go straight to mathematical results without any explanation.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2022

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.

Comments on individual questions/sections

Q.1 This question was the least well-answered question on the paper. In part (a), candidates seemed unprepared to differentiate $\cosh^3 x$ using the chain rule, with many candidates changing this into $\cosh^2 x \cosh x$ and then proceeding to use a $\cosh 2x$ identity. Candidates then used the chain rule to differentiate $\cosh 2x$ as part of a product. Some candidates used the exponential form of $\cosh x$. However, errors with the identities were seen frequently, leading to candidates losing accuracy marks. In part (b), candidates often found the second derivative and its value when $x = 0$, which was 0, and then continued on to state that this was a point of inflection.

Q.2 This question was answered poorly, with many candidates finding four fourth-roots, almost on auto-pilot. Few candidates realised there was a quicker method available, or that, if they did find the fourth-roots, that only two (separated by 180°) were required to calculate the radius.

Q.3 This question was one of the best-answered questions on the paper. Most candidates used the information from the Formula Booklet in part (a) to derive the required equation. In part (b), not all candidates showed sufficient working to solve their equation, and some candidates factorised incorrectly, often resulting in only one value of t.

Q.4 Most candidates gained full marks in this question. However, some candidates tried to work with πx^2, changing the limits and trying to integrate $\sin^{-1} x$, running into difficulties.

Q.5 Many candidates started well using row operations. However, some candidates failed to reach a row of 0 values, or made arithmetic errors. Other candidates, having reached a row of 0 values, did not interpret this correctly.

Q.6 Many candidates used the factor formula well to gain the initial marks. Some candidates seemed unfamiliar with the odd-function nature of $\sin\theta$ and worked with $\sin(-\theta)$ throughout; full marks were awarded if they correctly dealt with this. Other candidates cancelled through by $\sin\theta$ and lost solutions, and accuracy marks. While other candidates noted the general solutions, rather than the angles in the required range.

Q.7 In part (a), the majority of candidates were able to express the quadratic in the required form. However, some errors were made in obtaining the value of c, which was disappointing given that this skill is from GCE Mathematics Unit 1. In part (b), many candidates performed well, noting the connection between parts (a) and (b), with the main errors coming from extracting a factor of $\sqrt{4}$ from the denominator.

Q.8 This question was attempt by the majority of candidates by using the exponential form of $\sinh y$ and forming a quadratic equation in e^y to solve, but a few candidates worked with the identity $\cosh^2 y - \sinh^2 y = 1$. In both instances, candidates rarely justified their choice of the positive square-root, losing the final mark.

Q.9 In part (a), many candidates used the binomial theorem to expand the bracket correctly, although some changed it to $(C + iS)^2(C + iS)$ or $(C + iS)(C + iS)(C + iS)$ first, which often lead to errors. Furthermore, some candidates' use of de Moivre's theorem was unclear, such as why they chose the Real terms. In part (b), most candidates made use of the result in part (a), although most divided through by $\cos\theta$ without explaining why this was possible in this question, losing an accuracy mark. Furthermore, few noticed that the two possible general solutions could be combined, which lost the final mark.

Q.10 This question was a high-point for many candidates and was the best-answered on the paper. Full marks were often awarded. In part (a), errors occurred in calculating the determinant, particularly multiplying with 0, or solving their quadratic equation. In part (b), not all candidates seemed familiar with the term 'adjugate', with the cofactor matrix often given as the adjugate matrix.

Q.11 In part (a), (i) was answered very well, with the chain rule and product rule used effectively. However, (a)(ii) proved more problematic. Many candidates used the $\cosh 2x$ identity to rewrite the question before attempting a differentiation – any valid method was credited if used correctly. Whilst many candidates arrived at a correct derivative, some had errors in using the chain rule twice. In part (b), many candidates rearranged the equation into $y = \sqrt{\sinh x}$, rather than using implicit differentiation. Unfortunately, few candidates noted both $\pm$ options of the square-root, losing marks in the differentiation and values of y, $\frac{dy}{dx}$ and the equations of the tangents.

Q.12 This question proved to be a highlight for many candidates, with many good responses seen. However, carelessness on occasions with arithmetic lead to accuracy marks being lost. On some occasions, an inappropriate particular integral form was chosen and, sometimes, candidates failed to include their particular integral in the equation they were differentiating, losing many marks.

Q.13 In part (a), few correct sketches were seen. In part (b), most candidates used $y = r\sin\theta$, but not all, with some errors occurring in finding the derivative. In solving the trigonometric equation, some candidates did not state why they ignored the solution of $\cos\theta = \frac{1+\sqrt{3}}{2}$, while others only found one angle from $\cos\theta = \frac{1-\sqrt{3}}{2}$, losing accuracy marks.

Q.14 This question was answered well by those who realised that partial fractions were required. However, a large number of candidates tried to use a substitution involving the denominator. Some candidates also stated the numerical answer without working – candidates should be reminded that answers without workings are rarely credited.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2022

Advanced

FURTHER STATISTICS B – A2 UNIT 5

General Comments

As one might expect, the standard was much higher for this paper than any other statistics paper in the series. It was pleasing to see many candidates scoring upwards of 70 marks, showing sound mathematical ability and reasoning. There were some candidates who found the paper challenging, but, on the whole, candidates did very well. Candidates are becoming familiar with non-parametric tests and were comfortable with confidence intervals. Question 7 was the question that caused most difficulty.

Comments on individual questions/sections

Q.1 This question was very well answered by the vast majority of candidates. There were a few candidates who attempted to use the t-distribution. Unfortunately, this did not get any credit beyond the marks for the mean and standard error.

Q.2 Part (a) was a routine process which was generally well answered. Some candidates used a binomial distribution for part (b), which was a neat way of tackling the problem. It avoided having to consider the '$\times 3$', which was often omitted. Parts (b) and (c) proved increasingly difficult. Some candidates were unable to arrive at $\mathrm{Var}(T) = 8\mathrm{Var}(X)$. Some candidates even used $\mathrm{Var}(T) = 8^2\mathrm{Var}(X)$. The common errors in part (c) included considering $2B - A$ rather than $B - 2A$, and treating A and B as if they only had one hive at each location. This lead to the correct value for $\mathrm{E}(U)$, but from incorrect working, i.e. $15 - 2 \times 15 = -15$.

Q.3 Question 3 proved to be the most accessible question on the paper. Errors in conducting the Mann-Whitney test were few and far between. As one would imagine, part (a) was the most difficult part of the question. Some common incorrect or incomplete answers were seen, including "it's paired data," or "Independent".

Q.4 Part (a) was extremely well answered. The vast majority of candidates were able to pick up six marks here. Part (b) was more challenging, with some common errors/omissions being "$\hat{p}$ is normally distributed" and "p is estimated and SE is estimated." This second example, of course, essentially says the same thing twice. Candidates found part (c) more challenging, but many candidates were still able to give fully correct responses. Candidates had to be careful with the inequality, that they rounded to the correct whole number of people. Errors in rounding were more prevalent when candidates formed an equation rather than an inequality.

Q.5 Many candidates were able to give excellent responses to this question. Some common errors included incorrect hypotheses and the incorrect interchangeability of 38 and 43.26. Dividing by $\sqrt{50}$ was also commonly omitted. Some candidates seemed unable to, or unwilling to, give a headline that the reporter could use. Correct answers for parts (b), (c) and (d) were all common; unfortunately, it was rare for candidates to score all four marks.

Q.6 Along with question 3, this question was extremely well answered. There were a small number of candidates who seemed unprepared to deal with a difference of 0 and this often lead to the upper critical value being 52. This was the only instance where categorical statements at the conclusion stage of a hypothesis test were allowed. This is because the question stated that the zoologist *will* abandon his studies on the basis of the test.

Q.7 Candidates found question 7 dramatically more difficult that the other questions. Part (a) was not well answered at all. Some candidates knew the distribution of $(X + Y)$, but were unable to proceed at all with the rest of this part. Part (b) was generally well done, with many candidates able to find $\mathrm{E}(T_1)$ and show that T_1 was a better estimator than X. Part (c) was not well answered at all. Although some candidates were able to show that T_2 was an unbiased estimator for α, most made the error of expanding $(1 - \lambda)(180° - Y)$, as opposed to realising that $1 - \lambda$ is a constant that can be squared and multiplied by $\mathrm{Var}(180° - Y)$
Part (iii) was not well done at all. Many candidates chose not to attempt this part. Those that did, made all kinds of errors from setting $T_2 = 0$ or $\mathrm{Var}(T_2) = 0$ as opposed to $\frac{\mathrm{d}}{\mathrm{d}x}\mathrm{Var}(T_2) = 0$. Considering whether the point $\lambda = \frac{1}{2}$ was a minimum or a maximum was not something that crossed the minds of most candidates.

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.
- Candidates are encouraged to familiarise themselves with unbiased estimators.

FURTHER MATHEMATICS

General Certificate of Education (New)

Summer 2022

Advanced

FURTHER MECHANICS B – A2 UNIT 6

General Comments

This is only the second paper to be sat for this new specification and so it was reassuring to witness that it was well received by most candidates. Although it turned out to be less accessible than the Summer 2019 paper, many high scoring scripts with exemplar responses were seen.

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.

Comments on individual questions/sections

Q.1 This was the least accessible question on the paper. In part (a), most candidates identified and used the result $a = v\frac{\mathrm{d}v}{\mathrm{d}x}$, with only occasional sign errors occurring and some forgetting to apply the chain rule when working out $\frac{\mathrm{d}v}{\mathrm{d}x}$. Several misconceptions and notational issues were also seen. For example,

$$a = \frac{\mathrm{d}v}{\mathrm{d}t} = -\frac{96}{(4x+9)^2} \qquad \text{and} \qquad a = v\frac{\mathrm{d}v}{\mathrm{d}t} = -\frac{2304}{(4x+9)^3}$$

Part (b)(i) was done very well, mainly by those candidates who were confident in part (a). Irrespective of earlier parts, (b)(ii) was very successful with almost all candidates managing to separate variables, obtain an expression for t and attempt a substitution to find T.

Q.2 Candidates demonstrated a very strong understanding of how to show that the motion was Simple Harmonic in part (a). The majority of mistakes made were in determining the centre of motion. Some opted to convert into the Harmonic form, which meant that the amplitude was easily deduced even if mistakes were made in determining the phase difference.

It was encouraging to see that almost all candidates correctly answered part (b).

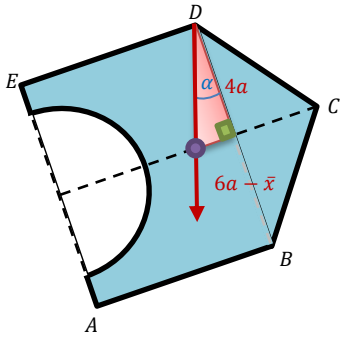
In part (c), most candidates easily established the correct form for the motion of particle *Q* and many correctly equated the two forms. A small number who used the Harmonic form were unable to progress to the final two marks.

Q.3 This was the most successful question on the paper. It was reassuring to see that candidates were not troubled by the algebraic context of the question.

Almost all candidates correctly wrote down the answer to part (a) by using symmetry.

In part (b), almost all candidates recognised the Pythagorean triple and also correctly subtracted the semicircle to get the final lamina. The most successful candidates constructed a simple table for $\bar{x}$ with columns for area and distance from AE.

For part (c)(i), the majority of candidates considered a simple sketch and so were able to identify the appropriate triangle. For example,



In part (c)(ii), a variety of attempts were seen, not all successful. Some went back to first principles, thus making the problem quite challenging. As expected, the most successful candidates considered the original lamina as a single mass positioned at a horizontal distance of $(6a - \bar{x})$ from BD.

Q.4 In part (a), almost all candidates successfully identified the trigonometric ratios corresponding to their chosen angle of either C or D. A small number of candidates considered the weights as masses and so $25g$ and $10g$ were occasionally seen.

Part (b) turned out to be relatively straightforward with the only issue being ambiguity over the direction of the reaction at A. Most high scoring candidates provided a supporting diagram with the angle clearly indicated.

Q.5 This was more accessible than the corresponding question on the 2019 paper. However, several misconceptions remain. In part (a), restitution was often erroneously applied to whole vectors as shown,

$$(\mathbf{i} + 3\mathbf{j}) - (-2\mathbf{i} - 5\mathbf{j}) = -\frac{2}{5}(\mathbf{u}_B - \mathbf{u}_A)$$

Consequently, some candidates had to deal with much more demanding, and often meaningless, equations. The most successful candidates produced a clear supporting diagram with before and after vectors shown, together with the line of centres.

Parts (b), (c) and (d) were generally done well, irrespective of any misconceptions in part (a). In part (c), many candidates found the velocity vector, $\mathbf{v} = -2\mathbf{i} + 3\mathbf{j}$, but did not calculate the speed as instructed.

Q.6 Candidates demonstrated a very strong understanding of how to apply Hooke's law in this 'two spring' setting. A variety of successful methods were seen throughout, with candidates using different notations and reference points for the various distances in the question.

In part (a), most candidates provided a sketch labelled with appropriate distances, enabling them to deduce that the total extension was $0 \cdot 8$.

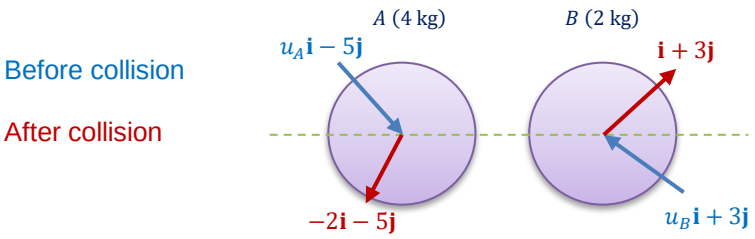
For part (b)(i), almost all candidates attempted to use Newton's second law with a net tension. However, many struggled to legitimately establish a general distance upon which to establish the Simple Harmonic Motion. The most proficient approach was to let x denote the displacement of P from C.

Part (b)(ii) also turned out to be accessible where the most frequent error was candidates incorrectly using $x = 0 \cdot 2$ for the point at which there is no tension in the spring AP. Therefore, many calculated a t based on $0 \cdot 2 = 0 \cdot 4 \cos 5t$.

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 questions. For example, in question 5,



- 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 a calculator.

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