# GCE EXAMINERS' REPORTS

## GCE (NEW)
## MATHEMATICS
### AS/Advanced

## SUMMER 2019

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## MATHEMATICS

## General Certificate of Education (New)

## Summer 2019

## Advanced Subsidiary/Advanced

## PURE MATHEMATICS A – AS UNIT 1

### General Comments

This paper seems to be comparable to last year's paper in length and difficulty. Candidates generally seemed to be reasonably well prepared. Generally speaking, the topics which were in the legacy specification were well done. However, there were still some topics that many candidates found difficult, such as logarithms and exponentials (question 10). The responses to questions 6 and 11, which are on new topics, were disappointing. Many candidates made no attempt at all on question 11. Question 15, on increasing functions, required knowledge from more than one topic and was probably the least well done question on the paper.

The majority of candidates adapted reasonably well to the more challenging problem-solving questions, although these types of questions proved too difficult for the weaker candidates, of which there were many.

Many candidates' responses would benefit from a good diagram. The general reluctance amongst candidates to spend time drawing good and properly labelled diagrams is noticeable. The lack of a diagram often leads to errors in the solutions as some facts, which become obvious with a diagram, escape the candidates' notice.

### Comments on individual questions/sections

Q.1 This question provided a good start to the paper. Some candidates lost marks unnecessarily by not showing their method for solving the resulting quadratic equation, presumably they solved it using their calculators.

Q.2 A similar question on last year's paper was very poorly answered, with hardly any correct answers seen. However, this question was much better received, though many candidates were not able to collect together the $x$ terms and to the identify the $a$, $b$ and $c$ correctly in order to write down the discriminant. Some candidates found the presence of the unknown constant $k$ a problem. Many candidates who correctly calculated the critical values were not able to find the correct inequalities and gain the final two marks.

Q.3 This topic was well known by candidates and so the approach used to answer the question was usually correct and there were very few careless errors (usually a sign error) in factorisation.

Q.4 This question was well done, except for the last part, which would have benefited from a good diagram. Many candidates either used the incorrect triangle, or put the right angle in the wrong place.

Q.5 Some candidates misunderstood the question and only considered $n = 2, 3$ instead of $n = 1, 2, 3, 4$. That, and forgetting to mention that the resulting numbers are prime numbers, were probably the only errors seen.

Q.6 This was one of the poorer answered question on the paper. Candidates did not seem to understand vectors well. This was disappointing as part (*a*) only required very basic knowledge of vectors.

Q.7 Part (*a*) was well done. In part (*b*), the numerical terms were often correctly dealt with, probably with the aid of the calculator. However, surprisingly many candidates were not able to simplify $\sqrt{b^2}$ , and sometimes candidates were clearly very careless with their presentation as it was sometimes not easy to distinguish whether the candidate had written $\sqrt{12b^2}$ or $\sqrt{12}b^2$ .

Q.8 In part (*a*), owing to carelessness with details, the last two marks were often lost. These two marks were only awarded for perfect presentation. Part (*b*) involved some simple differentiation and substitution and was well done.

Q.9 The algebra needed to deal with circles is generally well understood by candidates. Thus, this question was reasonably well done except for part (*d*). Candidates generally did not draw a diagram showing the circle and all the points clearly labelled. Consequently the position of the right angle was often incorrect, so that the diameter was often incorrectly used to find the area of the triangle required.

Q.10 Part (*a*) was probably the worst answered question on the paper. Many candidates attempted to take logs, which was one of the correct approaches. Unfortunately, although the power law was correctly applied, the addition law was not. This resulted in a pair of equations which were not linear and their solution proved beyond the capabilities of the candidates. Some nice solutions were seen, though not many. The responses to part (*b*) were as expected, with many candidates gaining the two B marks and then making no further progress.

Q.11 As in question 10, candidates knew that they needed to take logs and, here, it was both the addition law and the power law that was applied incorrectly. There were large numbers of 'no attempts' on this question.

Q.12 This was a reasonably well-done question, though many candidates thought there were eight terms instead of nine in the series. Often the incorrect term was picked in part (*c*). More disappointingly, many candidates found the entire series in order to pick the required answers, which must have wasted quite a bit of valuable examination time. Some candidates wrote out the complete Pascal triangle to find the required ${}^{8}C_r$ , instead of using the formula.

Q.13 Questions of this type often appeared in the legacy papers and were well done. As expected, this question was also well done generally, with very few errors, except careless ones, seen.

Q.14 Sine and cosine rules seem to be generally well known by candidates. To do this question efficiently, both rules were required. Errors were of two types: some candidates knew the sine rule, but not the cosine rule, whilst others knew the cosine rule, but not the sine rule.

Q.15 Responses to this question were disappointing. Many candidates knew that the crux of the matter was to show that the first derivative was always positive. There were a variety of methods available. Since the function was only a quadratic, candidates could find its minimum, either by means of the second derivative, or by completing the square. Alternatively, they could calculate the discriminant, which turned out to be negative, showing that the curve was either completely above, or completely below the $x$-axis, and then consider a single point on the curve.

Q.16 This question was reasonably well done. The most common error was integrating from $-1$ to $-2$, rather than the correct $-2$ to $-1$, resulting in a sign error in the answer to the integral.

**Summary of key points**

Generally speaking, the presentation of solutions by candidates is poor. A little more care should be taken with handwriting. It is not often possible to tell the difference between 5s and 8s, for example. This has an impact on the accuracy of solutions, as sometimes the candidates cannot read their own handwriting, resulting in transcription errors.

Candidates should be encouraged to draw clearly labelled and complete diagrams, wherever appropriate. The time spent on this is often well rewarded.

Standard proofs should be learnt with more care and attention to detail. For example, in the question on differentiation from first principles, it would be nice to see rather more perfect solutions.

**MATHEMATICS**

**General Certificate of Education (New)**

**Summer 2019**

**Advanced Subsidiary/Advanced**

**APPLIED MATHEMATICS A – AS UNIT 2 SECTION A**

**General Comments**

The variety of topics that the subject content for this unit offers meant that some questions on the paper seemed familiar to candidates and were generally well answered, whereas other questions seemed less familiar and were not as well answered. Once again, this year, questions involving insight, notably questions 2(*d*) and 4(*c*), were answered correctly by only a small proportion of candidates.

**Comments on individual questions/sections**

Q.1 This question was a familiar opening question which many candidates answered very well. A common error was to assume that the events *A* and *B* were independent which meant that $P(A \cap B) = 0$. This error lead to $P(A) = 0 \cdot 55$ and then subsequently to $P(A \cap C) = -\frac{7}{60}$. Many candidates were either unable to find and rectify their error, or were simply unaware that this was an invalid probability.

Q.2 This was, by far, the most poorly answered question on the paper. In part (*b*), all but the weakest candidates identified the binomial distribution $B(50, 0.3)$. From there onwards, the errors started to creep in. Some candidates thought an appropriate hypothesis test would involve evaluating $P(X = 21)$. This scored no further marks.

In part (*d*), the vast majority of candidates did not appreciate that, when conducting a hypothesis test, the hypotheses should be formed before looking at the data. This led to a plethora of incorrect answers, including "Ali should not need to worry about a hypothesis test because the percentage has now improved to 35%," which showed a complete lack of understanding about the whole process of hypothesis testing.

Q.3 Many candidates were comfortable answering part (*a*). When using the calculator to calculate cumulative probabilities for the binomial distribution, candidates should be aware that the calculator gives $P(X \leq x)$. One of the most common errors in this part of the question was to identify the first value for $X$ that gave an answer less than 0.09 and then to conclude that $n = 3$, or even $n = 4$. This question required finding $P(X \geq x) < 0 \cdot 09$ which involved subtracting the value given by the calculator from 1. Part (*c*) was surprisingly well answered.

Q.4 Part (*a*) proved to be very accessible, with many candidates offering thoughtful answers to (ii). Although candidates are required to calculate the mean from a grouped frequency table at GCSE level, this was not evident here. Calculating the standard deviation would have been less familiar to candidates and this was equally poorly attempted. Surprisingly, some candidates managed to calculate the standard deviation, but were unable to identify the mean. In part (*c*)(ii), despite many candidates making the error of agreeing with Angharad, most candidates could identify that the area was the important characteristic of a histogram, but were unable to comment on the uncertainty of Angharad's statement in enough detail.

Q.5 Despite seeing many good responses to individual parts of this question, very few candidates were able to answer the whole question correctly. Common errors included calling Huw's sampling "stratified sampling", telling Huw to ask every $10^{th}$ person he saw on the street (which was clearly impractical), and using 889 000 in the regression line.

**Summary of key points**

- Candidates are encouraged to consider whether their answers are reasonable. Candidates should not be content with answers that include negative probabilities, or probabilities greater than 1.

- Candidates should familiarise themselves with hypothesis testing developed through a binomial model.

- It was disappointing that candidates were not able to recall some of the subject content from the GCSE course.

- Calculators are a useful tool to aid the calculation of probabilities from the binomial and Poisson distributions. Candidates are encouraged to be more adept at using the calculators effectively.

**MATHEMATICS**

**General Certificate of Education (New)**

**Summer 2019**

**Advanced Subsidiary/Advanced**

**APPLIED MATHEMATICS A – AS UNIT 2 SECTION B**

## General Comments

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 answer Section B of the paper. All questions appeared to be generally accessible to most candidates, with the exception of questions 7(*c*) and 9(*b*) which only a minority were able to tackle successfully.

Many exemplar solutions were seen for all of the questions in Section B.

## Comments on individual questions/sections

Q.6 Part (*a*) was answered extremely well, with almost all candidates making the correct initial decision to find the resultant of the three forces. However, it was concerning to see that some simplified $\mathbf{F} = (11 + a)\mathbf{i} + (b-5)\mathbf{j}$ to $\mathbf{F} = 11a\mathbf{i} - 5b\mathbf{j}$.

A small number of candidates did not consider the resultant, but instead applied Newton's second law to each individual force separately, i.e. $\mathbf{F}_2 = 2(7\mathbf{i} - 3\mathbf{j})$.

Many were comfortable with the requirements of part (*b*), yet were unable to communicate their solution mathematically, e.g.

$$14\mathbf{i} - 6\mathbf{j} = 0 \quad \therefore \quad \mathbf{F}_4 = -14\mathbf{i} + 6\mathbf{j}$$

Q.7 Parts (*a*) and (*b*) of this question were generally well done considering that this was the first time that a displacement-time graph has featured in the assessments for the reformed specification. Disappointingly, a small number of candidates were unable to deduce the total distance travelled.

Only a small number of candidates were able to successfully answer part (*c*)(i) with an even smaller proportion answering (*c*)(ii) correctly. In some responses, it was clear that the graph was mistaken for a velocity-time graph. The question was designed to examine candidates' understanding of concavity and the fact that speed and velocity will only differ when the velocity is negative. Hence, the solution to (*c*)(ii) was a subset of (*c*)(i).

Q.8 Overall, candidates were comfortable in selecting and applying the appropriate formulae for vertical motion under gravity. The majority of errors were due to not selecting a clear sign convention.

Remarkably, a significant number of candidates did not opt for the most efficient solution to part (*b*). Instead, the upward and downward motions were considered separately. Since this involved two applications of the constant acceleration formulae, this approach was less successful.

Correct answers to part (*c*) were generally accompanied by a correct response to part (*d*).

Q.9 This was the least accessible mechanics question on the paper. However, part (*a*) was very successful, with almost all candidates recognising that integration was required to obtain an expression for the velocity. Also, in comparison to Summer 2018, candidates were much more adept at finding the unknown constant using the initial conditions.

Responses to part (*b*) were generally disappointing. The success of part (*a*), together with the low standard deviation for the question overall, support this fact. Many did not take advantage of the fact that acceleration was constant for $t > 5$. Consequently, many replicated the 'calculus' method used in part (*a*) with the same, albeit incorrect in this instance, initial conditions, to get

$$v = \int 2\mathrm{d}t = 2t + 12 \, .$$

Therefore, the incorrect answer of $v = 2(14) + 12 = 40$ was frequently seen.

Q.10 This was by no means a straightforward question as it was designed to assess problem solving (AO3), incorporating algebra with the additional challenge of two possible scenarios. Nevertheless, this did not impact on the accessibility of the question as it was the most successful on the entire paper.

In general, candidates comfortably used Newton's second law to isolate each particle to set up two equations. The unknown mass of particle *B* rarely posed a problem.

Two approaches were used, roughly in equal measure. One method was to find $T$ immediately, following the application of Newton's second law to particle *A*. The alternative method was to apply Newton's second law to both particles, then solve the resulting equations simultaneously by eliminating $T$ to find $M$. The first method was the most successful, possibly as less algebraic manipulation was required.

Many candidates only considered one possible case for the acceleration of the system.

Part (*b*) was generally well answered, with most recognising that the tension would be influenced, as opposed to the acceleration.

**Summary of key points**

- Many candidates made preventable sign errors as they did not decide on a sign convention before attempting their solution. A clear comment at the outset such as '*take down as positive'* would be helpful.
- Many candidates continue to use incorrect mathematical notation.
- Some candidates struggled to provide alternative modelling assumptions, since air resistance had already been mentioned in the question.
- Knowledge and understanding of concavity were disappointing.

## MATHEMATICS

## General Certificate of Education (New)

## Summer 2019

## Advanced Subsidiary/Advanced

## PURE MATHEMATICS B – A2 UNIT 3

### General Comments

This paper seems to be broadly comparable to last year's paper on this reformed specification. This is the first year where there is a full cohort so that, predominantly, it is being sat by 18-year olds and not 17-year olds. Candidates appeared to be reasonably well prepared. Numerous good solutions to all the questions were seen, indicating that all of the questions on the paper were accessible to the candidates. However, there were a few marks which were only gained by the best candidates. The questions involving more than one topic, or the necessity to translate the requirements of the questions into mathematics, were less well done.

### Comments on individual questions/sections

Q.1 This was a well-done question. Pleasingly, there were very few candidates who started with the incorrect form of the partial fractions. Most of the errors were algebraic or careless ones. In part (*b*), almost all the candidates realised that the partial fractions form should be integrated, although there were some errors in integrating $\frac{3}{(x+2)^2}$, and some candidates forgot the constant of integration which lost them a mark.

Q.2 The binomial expansion is well understood and the formula was effectively applied. Many candidates tried to expand $(4-x)^1$ using the binomial formula and strangely did not always arrive at $(4-x)$, but made the problem much more difficult by arriving at the first four terms of a series.

Q.3 Part (*a*) was well done, though not invariably so. In part (*b*), many candidates assumed that if the sequence was not an arithmetic progression, then it must be a geometric progression and vice versa. Even more were not able to succinctly explain the reasons why the series was neither an arithmetic progression nor a geometric progression, so many erroneous statements, as well as many that did not make any sense, were seen.

Q.4 This question was on a topic that was in the legacy specification and, as such, was well done generally. Part (*b*) was less well done than the other two parts as some candidates went back to the original expression, so that finding the maximum denominator was not trivial. A variety of wrong methods were seen.

Q.5 In part (*a*), many candidates were able to correctly write down the two algebraic inequalities equivalent to the modulus inequality. However, in solving these inequalities, a very common error was to forget to reverse the inequality when multiplying throughout by a negative number.

In part (*b*), candidates were generally able to draw a V shape graph with the minimum below the $x$-axis. However, many candidates did not obtain the correct minimum point.

Q.6 In part (*a*), most of the error was in evaluating the trigonometric functions at $\frac{\pi}{4}$.

Some candidates did not simplify these expressions before using them to find the equation of the tangent which made the equation extremely complicated and careless mistakes were numerous.

Inexplicably in part (*b*), many candidates tried to find the point of intersection between the given line and the tangent found in part (*a*). This was not what was required by the question.

Q.7 Some very carelessly drawn graphs were seen, but, on the whole, this question did not cause problems for the candidates, though the transformed graphs often did not look much like the original version.

Q.8 Part (*a*) required knowledge of both arithmetic progression and geometric progression to be applied and many candidates found this very confusing. For those who managed to apply their knowledge of both types of series, often the resulting equations were not the most efficient ones so that the algebra turned out to be more complicated than it needed to be.

Candidates mostly did recognise that they were dealing with an arithmetic progression in part (*b*). Those who did not and tried to answer the question by pure reasoning often made the mistake of increasing the numbers from day 1 instead of day 2, getting the answer 580, instead of the correct 568. Disappointingly, many who had the correct series, were not able to use it to answer (ii) correctly.

Q.9 Part (*a*) was a simple trigonometric identity. The proof required $\tan(\alpha+\beta)$ to be expanded and the given condition manipulated to get $\tan\alpha\tan\beta = 2$. However, this was not well done, with candidates going around in circles.

In contrast, part (*b*) was a standard trigonometric equation and was done well.

Q.10 The product, quotient and chain rules for differentiation are well known, as is implicit differentiation. However, candidates made many careless errors in their application. In particular, essential brackets were often omitted making the answers incorrect. This was particularly marked in (*a*)(iii) where candidates applied the chain rule correctly, but omitted the bracket round $\left(\sec^2 x + 7\right)$. Many marks were lost unnecessarily in this question.

Q.11 Most candidates did have the correct approach. However, the simple bit of algebra required to do this question successfully did cause great difficulties to the candidates. As did the sketching of the required graphs. Not many correct graphs were seen.

Very few candidates got the correct range for $f(x)$, and so the mark for the domain of $f^{-1}(x)$ was lost. This also led to the loss of the mark in part (*b*). Owing to the lack of the correct graphs in part (*a*), part (*b*) was very badly done.

Q.12 Part (*a*) can be very simply done by equating the area of the minor segment to $\frac{1}{3}$ of the area of the circle. Many candidates obtained the area of the minor segment and did not know how to proceed thereafter, or chose the more difficult route of involving the major segment, making lots of algebraic errors on the way.

Part (*b*)(i) was well done generally. Candidates who knew the Newton-Raphson iterative formula, or remembered to look it up in the Formula Booklet, did this question well. There were a few candidates who gave an incorrect form, or used an incorrect $f(x)$, often leaving out a term.

Q.13 This question was surprisingly well done. The last two marks were often lost by incorrect inversion of $\ln$ to get an expression for $A$ in terms of $\mathrm{e}$. There were also some errors with combining the two $\ln$ terms which appeared after the use of the first set of conditions.

Q.14 This question on integration was reasonably well done. The methods for integration were well known to the candidates. Part (*b*) caused some difficulties as candidates did not spot that the answer can be just be written down. In part (*d*), some candidates did not like integrating from 3 to 2 and reversed the order thus obtaining a negative answer.

Q.15 This was bookwork; a proof that needed to be learnt. The responses revealed that candidates did not pay sufficient attention to the details of the proof. In particular, after assuming that $\sqrt{6} = \frac{a}{b}$, the fact that $a$ and $b$ have no common factors was often omitted. Nevertheless, candidates, after showing that $a$ and $b$ did have a common factor, went on to conclude that this was a contradiction.

**Summary of key points**

Many marks are unnecessarily lost due to careless algebraic manipulation, and carelessness when applying standard techniques. The omission of important brackets is also widespread.

More care is needed in the sketching of graphs, especially in questions where graphs are being transformed. The transformed graph needs to bear some relationship to the original version. Points need to be clearly labelled and attention paid to the position of asymptotes, that they are not being crossed by the graphs.

Many errors result from candidates not remembering the important formulae accurately. For example, $\cos 2\theta$ was often expanded to $2\sin^2\theta - 1$. This kind of error often makes the question more difficult to solve, losing many accuracy marks, though follow through marks are awarded.

As expected, problem-solving questions were less well done generally.

**MATHEMATICS**

**General Certificate of Education (New)**

**Summer 2019**

**Advanced Subsidiary/Advanced**

**APPLIED MATHEMATICS B – A2 UNIT 4 SECTION A**

## General Comments

This paper proved rather challenging for many candidates. As one would expect, there were also some well answered scripts. It was evident that candidates were not accustomed to thinking critically about their work. The new specification requires more thought to be given to questions and their corresponding answers rather than following processes as a matter of routine. Questions that required explanation were, once again, the least well answered.

## Comments on individual questions/sections

Q.1 This question was the most well answered question of the statistics section of the paper. Candidates were adept at using their answers from part (*a*) in part (*b*). There were a small proportion of candidates who had trouble with the ratio aspect of the question, with some assuming each probability was to be multiplied by $\frac{1}{3}$ rather than the appropriate proportions from the question. Some were able to miscount the number of parts of the ratio, but still end up with the correct answer in part (*b*).

Q.2 This question was slightly less well answered than question 1, but still proved to be accessible to most candidates. All but the weakest candidates correctly answered part (*a*)(i). Most candidates were able to give good attempts at parts (ii) and (iii), but lost track of how many turns each player had taken, which led to parts of the solution being correct, but falling short of a fully correct solution. Many candidates seemed unwilling or unable to use fractions and ended up losing accuracy, especially when rounding each individual part of the answer to two decimal places. Candidates are reminded that they should round their final answer to an appropriate degree of accuracy, rather than at any intermediate stage.

Q.3 Most candidates were able to gain some marks in this question. It was somewhat surprising to see that, although candidates could give one assumption, they were not often able to give both the assumption of independence of events and a constant probability of success for a binomial distribution in the context of the question. Candidates were often able to give one way that the distribution changed in part (*b*), but not two ways. It should be noted that the distribution does not become a normal distribution, but rather, it can be approximated by a normal distribution.

Q.4 Most candidates were able to answer part (*a*) correctly by using the calculator. Candidates who went down this route, but did not arrive at the correct answer, forfeited the method mark. Part (*b*) was the most challenging part of this question, with a considerably larger proportion of candidates than expected unable to use the correct limits. The realisation that the distribution of $\bar{X}$ was required to answer this part was not common. A variety of methods were used in part (*c*), with some common errors being incorrect hypotheses, for example, $H_0 = 16 \cdot 02$ and $H_1 \neq 16 \cdot 02$, comparing *p*-values to critical values, and not accounting for the two-tailed nature of the test.

Q.5 Part (*a*) provided a good opportunity for candidates to gain marks with many candidates able to produce fully correct solutions. Some candidates miscounted the number of points and some candidates were unsure how to work out the correct value for $n$. In part (*b*), candidates were often able to state that there was correlation between fish consumption and bowling alley revenue, but did not reference the *p*-value. By far the most common error was to not consider the irrelevance of the findings in parts (*a*) and (*b*).

**Summary of key points**

- Candidates should always consider the reasonableness of their answers. This includes recognising that probabilities should be between 0 and 1, and assessing the suitability of conclusions resulting from hypothesis testing.

- It was encouraging to see candidates engaging well with probability questions. However, candidates are encouraged to develop the mathematical skills and understanding associated with conditional probability.

- Candidates are encouraged to recognise when the distribution of the sample mean should be used to answer questions.

- It would be of benefit to candidates to learn the assumptions of a binomial distribution and a Poisson distribution and be able to apply them in context.

**MATHEMATICS**

**General Certificate of Education (New)**

**Summer 2019**

**Advanced Subsidiary/Advanced**

**APPLIED MATHEMATICS B – A2 UNIT 4 SECTION B**

## General Comments

The paper allowed candidates of all abilities to display their knowledge and demonstrate their mathematical skills. Many exemplar responses were seen for all of the questions in Section B.

The attempt rate for some questions suggests that time may have been an issue for some candidates, or some may have invested too much time on questions earlier in the paper.

Notably, question 8 and question 10 were the most demanding of the mechanics questions, whilst question 7 was by far the most successful.

## Comments on individual questions/sections

Q.6 Part (*a*) was generally well answered, with almost all candidates making the correct decision to differentiate $\mathbf{v}$ and then use Newton's second law.

Responses were less successful for part (*b*), with a variety of different errors occurring. Many struggled to find the constant of integration in a vector setting with some simply stating that $\mathbf{c} = 4\mathbf{i} + 7\mathbf{j}$. More seriously, some candidates used $\mathbf{v}$ and their expression for $\mathbf{a}$ from part (*a*), along with $\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ to get expressions similar to

$$\mathbf{s} = \left(12\cos(3t)\mathbf{i} - 5\sin(2t)\mathbf{j}\right)t + \frac{1}{2}\left(-36\sin(3t)\mathbf{i} - 10\cos(2t)\mathbf{j}\right)t^2 .$$

As expected, sign errors were common throughout the entire question.

In part (*c*), almost all candidates made the decision to substitute $t = \frac{\pi}{2}$ into their expression for $\mathbf{s}$, but many gave their final answer as $\mathbf{r} = 2\mathbf{j}$, thus forfeiting the final mark awarded for the distance *OP*.

Q.7 This was the most successful question on the paper. Notably, the scores for this question had a small standard deviation, thus suggesting that responses were consistent.

In part (*a*), most candidates used the trigonometric ratios to deduce that $\sin\alpha = \frac{3}{5}$ and $\cos\alpha = \frac{4}{5}$. However, some candidates evaluated $\alpha = 36.9^\circ$ to one decimal place. Whilst this approach can often be inefficient, fortunately, in this instance, it did not result in any loss of accuracy marks.

Part (*b*) saw some longer responses than were necessary for 1 mark, yet candidates demonstrated very good knowledge of the principle being examined.

Q.8 Given that this was a basic differential equation, it was disappointing to see that efforts were generally poor in this question. Part (*a*) was well received. However, in part (*b*), many struggled to legitimately separate the variables. Furthermore, for those candidates who were successful in separating the variables, many made sign errors when integrating $v^{-2}$.

Unfortunately, a large proportion of candidates did not attempt part (*c*), mainly because they failed to get a final result in part (*b*).

Q.9 It was reassuring to see that candidates were not overly troubled by the context of this question. The majority of errors were attributed to either sign errors or poor mathematical notation.

In part (*a*), many dealt with moments about a point, but initially excluded the $T_i$ term. For example, for taking moments about wire 2, the following was seen:

- $mgd_C = mg(1+d_A) + mg(1-d_B) \Rightarrow T_1 = mg(1+d_A) + mg(1-d_B) - mgd_C$
- $mg(1+d_A) + mg(1-d_B) - mgd_C = 0 \Rightarrow T_1 = mg(1+d_A) + mg(1-d_B) - mgd_C$

Many sign errors stemmed from incorrectly identifying the direction of certain moments and also from rearranging equations, with many having to ‘tinker’ with their solution to try to convince examiners of the printed result for $T_1$.

Remarkably, a significant number of candidates did not opt for the ‘standard’ solution. Instead, two applications of moments were considered: one about wire 1, another about wire 2. For those who made mistakes in setting up a ‘moments’ equation, this approach was much less successful than resolving forces vertically.

Q.10 Unfortunately, this was the least accessible question on the whole paper. The specification now covers the formulae for constant acceleration for motion in a straight line for 2 dimensions using vectors. Thus, for this question on the projectile of a tennis ball, two possible approaches were possible. Very few candidates opted for the vector method using $\mathbf{a} = -g\mathbf{j}$. The vast majority elected to work with the horizontal and vertical components separately in keeping with the approach for the legacy specification. Therefore, the performance of this particular question was disappointing. Overall, candidates were comfortable in selecting and applying the appropriate formulae, but most of the errors were due to candidates not selecting a clear sign convention and not realising that the point of projection was not the origin.

Part (*a*) was generally well answered. Part (*b*) was less successful and $\mathbf{s} = 12\mathbf{i} - 1\cdot344\mathbf{j}$ was often seen, instead of $\mathbf{s} = 12\mathbf{i} - 1\cdot344\mathbf{j} + 2\cdot4\mathbf{j}$.

It was disappointing to see some candidates forgetting the acceleration altogether by simply integrating the velocity vector, i.e.

$$\mathbf{s} = \int (30\mathbf{i} - 1\cdot4\mathbf{j})\mathrm{d}t ,$$

leading to $\mathbf{s} = 30t\mathbf{i} - 1\cdot4t\mathbf{j} + \mathbf{c}$ $\Rightarrow$ $\mathbf{s} = 30t\mathbf{i} - (2\cdot4 - 1\cdot4t)\mathbf{j} + \mathbf{c}$.

Sadly, possibly due to time issues, a very large proportion of candidates did not attempt part (*c*). However, almost all of those who attempted it were able to successfully answer both parts of the question. 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.

**Summary of key points**

- Marks continue to be lost due to incorrectly separating the variables in a differential equation.
- Candidates need to be reminded that the equations of motion can only be used for constant acceleration $\mathbf{a}$ .
- The most successful candidates used the trigonometric ratios associated with $\tan\alpha = \frac{3}{4}$, rather than evaluating $\alpha$ .
- Some candidates did not consider the sensibility of their responses by referring back to the original model. For example, some suggested playing a game of tennis in a vacuum.

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