

# GCE Examiners' Report

Further Mathematics

GCE

Summer 2025

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## Introduction

Our Principal Examiners' report provides valuable feedback on the recent assessment series. It has been written by our Principal Examiners and Principal Moderators after the completion of marking and moderation, and details how candidates have performed in each unit.

This report opens with a summary of candidates' performance, including the assessment objectives/skills/topics/themes being tested, and highlights the characteristics of successful performance and where performance could be improved. It then looks in detail at each unit, pinpointing aspects that proved challenging to some candidates and suggesting some reasons as to why that might be.<sup>1</sup>

The information found in this report provides valuable insight for practitioners to support their teaching and learning activity. We would also encourage practitioners to share this document – in its entirety or in part – with their learners to help with exam preparation, to understand how to avoid pitfalls and to add to their revision toolbox.

## Further support

Document	Description	Link
Professional Learning / CPD	WJEC offers an extensive programme of online and face-to-face Professional Learning events. Access interactive feedback, review example candidate responses, gain practical ideas for the classroom and put questions to our dedicated team by registering for one of our events here.	<a href="https://www.wjec.co.uk/home/professional-learning/">https://www.wjec.co.uk/home/professional-learning/</a>
Past papers	Access the bank of past papers for this qualification, including the most recent assessments. Please note that we do not make past papers available on the public website until 12 months after the examination.	<a href="#">Portal by WJEC</a> or on the WJEC subject page
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<sup>1</sup> Please note that where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

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## Executive Summary

The examination papers in GCE Further Mathematics were generally of a similar standard to previous examination series. As is always the case, some questions were more demanding in some topics than in previous series, whilst others were less demanding. It was pleasing to see that, unlike in the previous few series, this year, candidates embarking on the AS / A2 Further Mathematics course were better at recalling and applying their knowledge and understanding of AS / A2 Mathematics, and therefore were more successful in answering questions that required this pre-requisite knowledge.

There are some areas of the subject content that are not well understood each year and this year was no exception. These include topics such as the exponential distribution, vertical circles, and summations with fractional terms. Other topics that are specific to units are listed in the individual unit reports. Similarly, there are certain skills that are lacking each year which can prove costly, e.g. algebraic manipulation and the reluctance to draw diagrams.

Similar to previous series, questions that were set in a non-standard format, i.e. in context, both mathematical and non-mathematical, proved challenging for candidates. They struggled to translate the information given in the question into the relevant mathematical processes. These problem-solving styles of questions require a deeper understanding of the underlying mathematics, than simply following routine processes and procedures.

Overall, candidates performed better on the exam papers this series, and many excellent solutions were seen to all questions in all six GCE Further Mathematics units, e.g. matrices (Units 1 and 4), least squares regression (Unit 2), Hooke's law (Unit 3), parametric tests (Unit 5) and centre of mass (Unit 6).

# FURTHER MATHEMATICS

## GCE

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### AS UNIT 1 FURTHER PURE MATHEMATICS A

#### Overview of the Unit

Many candidates performed very well on this paper and some excellent scripts were seen. As in previous series, poor algebraic manipulation proved costly at times, and carelessness in reading their own work hindered the progress of some candidates. Each question proved accessible to candidates, although candidates seemed unprepared at times to review their answers and consider whether they had answered the question fully.

Questions on the following topics were well answered:

- Roots of equations (Q1)
- Vector equations of lines (Q2)
- Matrices (Q5a)

Some candidates had difficulty with the following content:

- Summations (Q3)
- Complex numbers (Q4)
- Transformations and invariant points (Q7)

Areas for improvement:

- Algebraic manipulation
- Completeness of answers

#### Comments on individual questions/sections

- Q.1** Overall, this question was well-answered, but some candidates failed to heed the requirement in part (a) to show all workings when expanding  $(3 - 2i)$  to the powers of 2 and 3. In part (b), all the methods given in the mark scheme were seen, with those candidates using the sum of the roots method being the most successful. In part (c), algebraic manipulation errors proved costly for some candidates.
- Q.2** Part (a) was answered more poorly than expected. Some candidates did not show a method to find the equation of the line  $L_1$  and simply rewrote the equation given in the question. Many candidates failed to include ' $r =$ ' when writing the equation of  $L_2$ . In part (c), not all candidates seemed familiar with the modulus element of the formula for the perpendicular distance between a point and a plane, leaving their answer as a negative value.
- Q.3** In part (a), those candidates who appreciated that  $r$  began at 2 often progressed well, with only poor algebraic fraction work costing marks. However, some candidates began with  $r = 1$  and either ignored the expression, or encountered difficulties. In part (b), many candidates began well, but left their final answer as a decimal, not appreciating that  $n$  had to be a positive integer.
- Q.4** This question was well-answered by those candidates who realised that  $(a + ib)^2 = 7 - 24i$  was the correct starting point. From there on, candidates only lost marks due to careless mistakes when dealing with negative values.

- Q.5** This question was well-answered with only the tail end of part (b) proving problematic. Many candidates encountered difficulties in rewriting  $-(-1)^k$  as  $+(-1)^{k+1}$  and, consequently, lost the final two marks.
- Q.6** The beginning of this question was well-answered, with candidates often succeeding in expanding both sides of the equation. However, candidates were less successful when rearranging the equation, encountering difficulties with the algebraic coefficient of  $x$ . Furthermore, some candidates did not take into consideration that the coefficients of  $x^2$  and  $y^2$  were 8 when finding an expression for the  $x$ -coordinate of the centre, before solving for  $q$ .
- Q.7** Part (a) was well-answered, with the most common errors occurring in determining the reflection matrix. It was pleasing to see that very few candidates multiplied the matrices in the wrong order this year. Part (b) often began well, with candidates forming two simultaneous equations using their matrix from part (a). Whilst candidates often collected like terms and simplified expressions, very often candidates failed to explicitly show that the resulting equations were not consistent. As the question stated that there were no invariant points, no credit could be given for stating this again without proving that the expressions were not consistent. Poor algebraic manipulation often proved costly in part (b).

## FURTHER MATHEMATICS

### GCE

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## AS UNIT 2 FURTHER STATISTICS A

### Overview of the Unit

The standard of responses for this unit continues to improve year-on-year and attempt rates for all questions exceeded 98%. Fewer candidates seemed to struggle with the knowledge, skills and understanding required at this level and excellent responses were seen for all questions. Although many candidates scored 60 or above, few were able to score the very top marks, as they were unable to provide sufficient responses for questions requiring insight, understanding and explanation. Once again, questions assessing probability distributions and the exponential distribution proved challenging. However, questions assessing hypothesis testing and least squares regression were answered well overall.

Questions on the following topics were well answered:

- Linear combinations of independent random variables (Q1)
- Least squares regression (Q2)
- Calculating Spearman's rank correlation coefficient (Q4)

Some candidates had difficulty with the following content:

- Constructing probability distributions (Q3)
- Understanding and using the exponential distribution (Q6)

Areas for improvement:

- Giving explanations, justifications and interpretations of results, in context
- Being able to extract the necessary information in a question set in context, in order to translate it into the relevant mathematical processes

### Comments on individual questions/sections

- Q.1** Overall, candidates performed very well on this question, and many seemed at ease with expectations algebra. The question primarily involved understanding and using the mean and variance of linear combinations of independent random variables. In part (c), the predominant error was dealing incorrectly with the coefficient of  $Y$ , or adding the constant 1.
- Q.2** This was the best performing question on the paper. The vast majority of candidates were able to calculate the equation of the regression line correctly. The most common error was premature rounding of  $b$ , which led to inaccurate values of  $a$ . Some candidates calculated the regression line of  $x$  on  $y$ . The explanation in part (b) was often unsatisfactory, with many candidates stating that the estimate was unreliable because there was no data between 1000 and 1500, or that the points were not that close to a straight line.

**Q.3** Many candidates continue to struggle with forming probability distributions from given scenarios. The interpretation element of the question was generally better understood than in previous series, with many candidates able to deal correctly with the profit and cost aspects of the scenario. The difficulties arose when candidates tried to calculate the probabilities associated with a profit of £0 and –£3. Common incorrect answers for  $P(X = -3)$  were  $\frac{1}{8}$ ,  $\frac{1}{2}$  and  $\frac{1}{4}$ . This was either because they failed to take into account the pairing (1,1) on the spinners, or they counted (1,1) twice. Correct calculations for both  $E(X)$  and  $\text{Var}(X)$  from candidates' probability distributions were credited with method marks, provided candidates engaged with the cost of £3 at some point.

From a correct probability distribution in part (a), it was relatively straightforward to deduce that the prize should be reduced to £9. Some candidates attempted this from first principles by setting  $E(X) = 0$ , but were only able to secure the one mark available for a correct answer of £9.

**Q.4** Parts (a) and (b) were answered well. Some candidates gave generic statements in part (c)(i) without realising that this involved completing the hypothesis test started in part (a). In part (c)(ii), the subtle nuance that there was no association between height and distance jumped within the competition but that it was likely that taller people are more suited for triple jump, was lost on many candidates.

**Q5** In part (a), candidates seemed unfamiliar with output from statistical packages. Many thought that the  $p$ -value was negative, failing to realise that  $2.2e-16$  was the value written in standard form, and assumed that 'e' was the exponential constant. In part (a)(ii), many candidates referenced combining classes without mentioning expected values. Others thought that the sample size was small without realising that the sample was extremely large and it was the observed values that were small.

In part (b), the chi-squared test for independence was generally very well done. In part (c), whilst many candidates were able to state that women contributed more to the chi-squared contributions, only the more able and insightful candidates made reference to the fact that there were fewer Outlasting victories than expected and more Timing Out victories than expected.

**Q6** This was the most poorly answered question on the paper. In part (a), most candidates recognised the distribution, although many also referred to 'the continuous distribution'. Part (a)(iii) was assessing candidates' knowledge of  $F(x)$  for  $x < 0$ . A number of incorrect responses were seen, including some where there was no reference to  $x < 0$ . In part (a)(iv), some candidates tried to find the quartiles by calculating  $F(0.25)$  and  $F(0.75)$ , but most were able to make some progress in calculating the interquartile range. However, candidates then struggled to simplify the resulting expression and give their answer as an exact value in terms of  $k$ .

In part (b), candidates made numerous errors, including using an incorrect  $\lambda$ , trying to calculate  $P(Y < 1200) - P(Y > 600)$ , and substituting 600 and 1200 into  $f(x)$  before subtracting the resulting values.

## FURTHER MATHEMATICS

### GCE

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### AS UNIT 3 FURTHER MECHANICS A

#### Overview of the Unit

The paper was very well received and many high scoring scripts with exemplar responses were seen. The paper appeared to be accessible to almost all candidates, with very few marks that were only obtainable by the most able candidates. Attempt rates were consistently high for all questions, supporting the fact that sufficient time was available to complete the paper. Furthermore, the facility factors were strong across the entire paper, ranging from 65% to 85%. This suggests that this paper was more accessible than in Summer 2024 and in previous series.

Questions on the following topics were well answered:

- Using calculus to deal with vectors in 3D and application of the scalar product (Q1, 81% facility factor)
- Hooke's law and conservation of energy (Q5, 85% facility factor)
- Using the power equation in conjunction with a combination of forces both on the horizontal and on an inclined plane (Q6, 78% facility factor)

Some candidates had difficulty with the following topics:

- Application of the work-energy principle in conjunction with a real-life scenario on motion in a vertical circle (Q7, 65% facility factor)
- Momentum and impulse for one-dimensional collisions (Q2, 72% facility factor)
- Motion in a horizontal circle for problems on banked tracks (Q4, 69% facility factor)

Areas for improvement include:

- The use of exact values from calculators and the retention of accuracy to avoid marks being lost due to premature approximation.
- Use of diagrams. Candidates are still reluctant to draw helpful diagrams or even to annotate the diagrams that are provided in the question.
- Explanations and signposting in solutions

#### Comments on individual questions/sections

- Q.1** This question provided a gentle start to the paper. In part (b), some candidates were not aware of the correct units associated with  $\mathbf{F} \cdot \mathbf{v}$  and many did not provide units at all.

**Q.2** Overall, this was a successful question with almost all candidates attempting to follow the standard approach. The use of algebraic quantities for the mass of each sphere did not pose a problem. Disappointingly, very few candidates provided helpful signposting such as 'Using Conservation of Momentum' and 'Using Restitution'. Sign errors continue to be the main source of error mainly from assuming that  $A$  and  $B$  were moving in the same direction after the collision.

In part (b), most candidates were familiar with the meaning of impulse, with a small number providing negative final answers, possibly missing the fact that the magnitude was requested.

In part (c), many candidates struggled to articulate the mathematical reasoning required to support their answers, particularly as a range of values was required.

**Q.3** This question was successfully answered, particularly as it was structured with detailed scaffolding. In part (c), a small number of candidates concluded with  $t = 5$ , but did not proceed to find the associated distance between  $A$  and  $B$ .

**Q.4** Responses were generally disappointing in this question, especially since there was no tendency to sideslip. However, efforts were significantly improved compared to those for a question on 'Banked Tracks' that appeared in the Summer 2018 assessment.

For part (a), some candidates still erroneously opted to resolve perpendicular to the plane or along the plane, giving  $17\,150 = 1500g \cos \alpha$ . As expected, misconceptions in (a) were mirrored in (b).

**Q.5** This was the most successful question on the paper. Almost all candidates scored full marks on part (a). In part (b), most candidates correctly identified that the conservation of energy was required with three energy forms.

**Q.6** Part (a) saw many successful fully correct solutions. In part (b), it was promising to see that almost all candidates sketched an appropriate diagram and attempted to work parallel to the plane. In comparison to previous series, it was encouraging to see that far fewer candidates omitted the component of weight down the slope. Sadly, some candidates lost marks due to incorrectly solving the quadratic equation, whereas this could have easily been avoided by using a calculator.

**Q.7** Overall, this vertical circle question was the least successful question on the paper. However, the facility factor of 65% shows a significant improvement compared to previous series. The application to a real-life setting did not appear to pose a problem. However, combining the scenario with the work-energy principle in part (b) caused the most confusion.

## FURTHER MATHEMATICS

### GCE

Summer 2025

#### A2 UNIT 4 FURTHER PURE MATHEMATICS B

##### Overview of the Unit

Many candidates performed very well on this paper and many excellent scripts were seen. Each question proved accessible to candidates and, in contrast to previous series, algebraic manipulation was a strength in this year's paper. However, once again, candidates seemed eager to rearrange trigonometric expressions and equations using identities when this was not required instead of applying more efficient techniques, and, consequently, scored few marks when the resulting rearrangements were incorrect.

Questions on the following topics were well answered:

- Matrices (Q4)
- Derivatives including hyperbolic functions (Q7)
- Integration using partial fractions, completing the square or mean value (Q10)

Some candidates had difficulty with the following content:

- General solutions to trigonometric equations (Q2c)
- Integration by parts (Q3b)
- Second order differential equations (Q9)

Areas for improvement:

- Identifying when trigonometric manipulation is required
- Sketching graphs using polar coordinates

##### Comments on individual questions/sections

- Q.1** This question was very well-answered, but some candidates understood  $e^{x^2}$  to be  $(e^x)^2$ , and, consequently, were only able to score marks in part (b). Some candidates integrated correctly, but arrived at an answer of 1.463, seemingly from a calculator, and, unfortunately, were not able to earn the final mark in part (b).
- Q.2** Part (a) was answered well, although some candidates did not show sufficient working in expanding the expression for  $n = k + 1$  to earn the final mark for a completely correct proof. In part (b), from the binomial expansion of  $(\cos \theta + i \sin \theta)^4$ , many candidates immediately proceeded to state only the real values, thereby lessening the required subsequent simplification. In part (c), it was disappointing to see numerous candidates stating only the positive roots and, consequently, they were penalised for omitting the negative solutions. Few candidates used Method 2 in the mark scheme, or similar, in parts (b) or (c)(i).
- Q.3** Part (a) was well-answered, with only candidates who did not show the penultimate line in the mark scheme losing marks. When a result is given in the question, candidates are reminded that they must show sufficient working to ensure that their answer is convincing. In part (b), not all candidates noted the link with part (a) and therefore encountered significant difficulties in using integration by parts.

- Q.4** This question was a particular high point of the paper, with, typically, only careless errors being seen. In part (b), most candidates followed Method 3 in the mark scheme.
- Q.5** The performance on this question can be split into two categories. The first included candidates who used the identity  $\cosh 4y = 1 + 2 \sinh^2 2y$  and who, almost always, earned full marks. The second included candidates who began by using  $\sinh 2y = 2 \sinh y \cosh y$  and who rarely completed the question successfully.
- Q.6** This question was another well-answered question, although scoring 5 marks of the 8 available was a common occurrence. On these occasions, candidates encountered difficulty in manipulating  $\tan^2 x$  into an integrable form.
- Q.7** This question was answered more poorly than expected. In part (a)(i), candidates regularly omitted '2', the derivative of  $2x$ , which formed part of the chain rule, and, consequently, scored 0 marks. In part (a)(ii), whilst it was common for most candidates to score full marks, some candidates omitted '4' from the derivative of  $\sinh 4x$ , and, consequently, did not earn the relevant mark. In part (b), some candidates believed that the gradients of the tangent and normal multiplied to give 1, whilst others were unaware of how to obtain a value for  $y$ , in order to find the equation of the normal. Also, in part (b), candidates often rearranged the fraction to  $y = \cos x (\cosh x)^{-1}$  and then incorrectly used the derivative of  $\cosh^{-1} x$ , scoring very few marks.
- Q.8** This question was generally very well-answered. However, it was disappointing to see some candidates not showing workings to solve the cubic equation given in part (b), but instead simply noting the solutions  $t = 0, 3, 5$ , for which they were penalised.
- Q.9** This question was well-answered by many candidates. However, some candidates seemed unfamiliar with the forms of the complementary function and particular integral that were required. Some candidates included 'i' in their complementary function, whilst others used a particular integral of the form  $y = C \sin x$  – both errors were penalised. Some candidates progressed successfully until they had to evaluate  $\frac{1}{5} \cos \pi$ , which they did incorrectly, losing the final two marks.
- Q.10** In part (a)(i), not all candidates were able to show convincingly the equivalence of the expressions given in the question, and, therefore, did not earn the A1 for a convincing conclusion. Part (a)(ii) was very well-answered, with the vast majority of candidates using Method 1 in the mark scheme. However, candidates who decomposed the integrand into partial fractions incorrectly were penalised heavily. Pleasingly, most candidates remembered to include the constant of integration.
- Q.11** This year, although the attempts to sketch a curve given by a polar equation were of a better standard than in previous series, not all candidates were able to earn any marks in part (a). In part (b), candidates progressed well through the first 7 marks, but then often struggled to find the values of  $x$  and  $y$  needed to calculate the area of the required rectangle. This was compounded by poor sketches in part (a). Once again, candidates seemed reluctant to differentiate  $\cos^2 \theta$ , often rewriting this using double-angle identities, before differentiating. Candidates who made errors in unnecessary manipulation scored few marks.

## FURTHER MATHEMATICS

### GCE

Summer 2025

## A2 UNIT 5 FURTHER STATISTICS B

### Overview of the Unit

The standard of responses this year was comparable to those from last year and an improvement on previous years, but with less variation. Candidates did not perform quite as well on some questions, but neither did they perform as poorly on others. Candidates were well equipped, and appropriately prepared, for the rigour of the paper, with excellent responses seen for all questions. As was the case last year, questions assessing confidence intervals and the Wilcoxon Signed-Rank test were very well answered. Many candidates lost marks questions that required explanations. Question 7 on estimators proved to be the most challenging question, with many candidates making a strong start, but struggling with the latter half of the question.

Questions on the following topics were well answered:

- Wilcoxon Signed-Rank test (Q3)
- Confidence intervals for the mean of a large sample (Q1)
- Mann-Whitney U test (Q5)

Some candidates had difficulty with the following content:

- Interpreting time and speed in context in relation to probabilities (Q4)
- Recognising a binomial distribution in relation to estimators (Q7c and Q7d)

Areas for improvement:

- More depth in explanations, justifications and interpretations of results, for questions set in context
- Being able to extract the necessary information in a question set in a non-standard format, in order to translate it into the relevant mathematical processes

### Comments on individual questions/sections

- Q.1** Overall, this was a very well answered question. Candidates were comfortable calculating the confidence interval in part (a) and finding the smallest sample size in part (c). Generic comments were given in parts (b) and (d), such as '95% of the confidence intervals will contain the true value for  $\mu$ ', and 'I used the Central Limit Theorem.' Candidates are encouraged to relate their explanations to the context of the question. A minority of candidates incorrectly dealt with the inequality in part (c), leading to an answer of  $n = 384$ .
- Q.2** Although generally well answered, there were a minority of candidates who were unable to start this question. Candidates who were able to use the formulae for the mean and variance of a uniform distribution were usually able to arrive at the correct expression for  $E(X^2)$ . The difficulty came in part (b), with incorrect answers such as  $3E(X^2)$  and  $E(3X^2)$  commonly written.

- Q.3** This question was the best performing question on the paper. Candidates and teachers are reminded that the median difference being equal to zero is not the same as the medians being equal to each other. Candidates often had no trouble in conducting the Wilcoxon Signed-Rank test in part (a). In part (c), a few difficulties included not addressing the two-tailed nature of the test, and not being able to progress beyond stating the distribution for  $X - Y$ .
- Q.4** This question was generally well answered, with many candidates scoring full marks. Apart from the usual errors such as subtracting variances and incorrectly distinguishing between  $\text{Var}(aX)$  and  $\text{Var}(X_1 + X_2 + \dots + X_n)$ , many candidates struggled to distinguish between Ela being quicker than Mali and Mali being quicker than Ela. This led to errors in calculating the required probability, e.g. calculating  $P\left(X - \frac{X}{2} > 0\right)$  instead of  $P\left(X - \frac{X}{2} < 0\right)$ .
- Q.5** Overall, this question was very well answered. The main difficulty appeared to be stating the hypotheses. Candidates were required to say 'on average' or reference the median (mean was condoned) in hypotheses that were expressed in words. Losing the mark for the hypotheses led to candidates also losing the final mark.
- Q.6** In part (a), although many candidates failed to state a necessary assumption, the majority of candidates had little difficulty in progressing with the rest of the question and used the  $t$ -distribution to calculate the correct confidence interval. Candidates who failed to use the  $t$ -distribution lost several marks. Part (b) was answered correctly by almost all candidates. Overall, part (c) was answered well, although some incorrect comments included, 'almost all data is normally distributed,' and 'the small sample size means it's hard to know if it's accurate.'
- Q.7** Parts (a) and (b) were very well answered, but parts (c) and (d) did not perform as well. Numerous errors, including poor algebraic manipulation in part (d), resulted in very few responses scoring full marks. Consequently, this was the most poorly answered question on the paper.

In part (a), almost all candidates were able to score full marks. In part (b)(i), candidates were often able to show that  $T_1$  was an unbiased estimator for  $\theta$ . However, in part (b)(ii), some of the errors seen included, adding  $\frac{3}{9}$ , the complete omission of  $n$ , multiplying by  $\frac{n}{n-1}$  and not squaring the coefficient of  $\bar{X}$ .

In parts (c), some candidates incorrectly thought that  $Y \sim B(n, 0.8 - 2\theta)$ . Candidates who were unable to recognise that  $Y$  followed a binomial distribution made little progress.

In part (d), some candidates who had previously stated the correct binomial distribution and were able to determine  $E(Y) = n(0.8 - \theta)$ , struggled to find  $\text{Var}(Y)$ .

## FURTHER MATHEMATICS

### GCE

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### A2 UNIT 6 FURTHER MECHANICS B

#### Overview of the Unit

The paper was very well received and many high scoring scripts with exemplar responses were seen. The paper appeared to be accessible to almost all candidates, with very few marks that were only obtainable by the most able candidates.

Attempt rates were consistently high, supporting the fact that sufficient time was available to complete the paper. Furthermore, the facility factors were strong across the entire paper, ranging from 55% to 78%. This suggests that this paper was more accessible than that in Summer 2024 and in previous series.

Questions on the following topics were well answered:

- Forming, solving and interpreting differential equations (Q1, 75% facility factor)
- Moments and centre of mass for 2D composite shapes (Q3, 78% facility factor)
- Restitution and Conservation of Momentum for 2D collisions using vectors (Q2a)

Some candidates had difficulty with the following topics:

- Determining the impulse for 2D collisions using vectors (Q2b)
- Application of proof to Simple Harmonic Motion by forming and solving differential equations (Q4a)
- Equilibrium of rigid bodies in a 'cliff face' scenario (Q5)

Areas for improvement include:

- The use of exact values from calculators and the retention of accuracy to avoid loss of marks due to premature approximation.
- Use of diagrams. Candidates are still reluctant to draw helpful diagrams or even to annotate the diagrams that are provided.
- Explanations and signposting in solutions

#### Comments on individual questions/sections

**Q.1** This was one of the most successful questions on the paper, with intermittent sign errors being the main source of inaccuracy. Some candidates 'lost' zeros at various points in their solutions.

Part (a) caused more issues than anticipated, as it required the knowledge and use of  $P = Fv$ , which is synoptic content from Unit 3.

**Q.2** Candidates' performance in 2D vector collision questions continues to improve and hence many exemplar responses were seen. A small number of candidates still apply the restitution equation to 'whole vectors' resulting in much more demanding and meaningless equations. Sign errors are still the most frequently made mistake. The most successful candidates stated the necessary equations algebraically, before attempting to substitute in the numerical values.

Many candidates did not achieve full credit in part (b), since they concluded with an impulse of  $14m$  Ns, without specifying a direction. The impulse is a vector quantity and so  $14m\mathbf{i}$  Ns was required.

**Q.3** Candidates continue to demonstrate a strong aptitude when applying moments and centre of mass in a 2D setting. Historically, questions on this topic have always performed well and this question continued the trend. With a high facility factor of 78%, this was the most successful question on the paper. However, some candidates did not recognise that the lamina,  $L$ , was of density  $2\rho$ .

**Q.4** A significant number of candidates were unfamiliar with the process of forming and solving differential equations to arrive at the familiar Simple Harmonic Motion equations given in the question.

In part (a)(ii), some candidates started with the given result and proceeded to verify that it satisfied  $\frac{d^2x}{dt^2} = -\omega^2x$ . Unfortunately, this does not constitute a mathematical proof. Many candidates legitimately started with the auxiliary equation  $r^2 + \omega^2 = 0$ , leading to  $x = e^{-\omega t}(A \cos \omega t + B \sin \omega t)$ . Most were able to deduce that  $A = 0$ , but were unconvincing in showing that  $B = a$ .

**Q.5** This was the least accessible question on the paper, possibly due to it being set in an unfamiliar context. On average, candidates only secured 55% of the marks available. This question provided the perfect opportunity to provide answers in exact forms, yet very few candidates opted to do so.

In part (a), some candidates fortuitously arrived at the correct answer of  $T = 611 \cdot 06(7 \dots)$  by resolving parallel to  $BC$  using  $T = 72g \sin 60^\circ$  and ignoring the contact forces at the point  $A$ . Of course, this earned no credit. This occurred as the angle of friction (the direction of the resultant of the normal reaction and friction) was also inclined at 60 degrees to the vertical.

Since the centre of mass of the person coincided with the point at which the rope was attached, an efficient solution was possible. Taking moments about  $B$  gives

$$F \times 0 \cdot 8 \sin 60^\circ = R \times 0 \cdot 8 \cos 60^\circ,$$

leading to

$$\mu = \frac{F}{R} = \frac{1}{\tan 60^\circ} = \frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3} = 0 \cdot 577(35 \dots).$$

Only a handful of the most able candidates opted for this approach.

In part (b), signposting was generally poor. Candidates should be encouraged to write statements such as

- Resolving vertically / horizontally
- Taking moments about  $B$
- Using  $F = \mu R$  for limiting friction

6. In part (a), a small number of candidates needlessly derived the equation for the volume of a cone, thus wasting valuable examination time. Furthermore, some responses were ambiguous, as it was not clear if the  $\pi$ 's had been cancelled. For example,

$$\bar{x} = \frac{\int_0^h xy^2 dx}{\frac{1}{3}r^2h}.$$

Candidates who worked with a function in  $x$  and rotated about the  $x$ -axis were more successful than those who considered rotation about the  $y$ -axis.

In part (b), it was reassuring to see that candidates were not troubled by the fact that the shape was not symmetrical. Most candidates constructed a table including the mass of the shapes, together with their corresponding distance from both  $OX$  and the plane face.

## Supporting you

### Useful contacts and links

Our friendly subject team is on hand to support you between 8.30am and 5.00pm, Monday to Friday.

Tel: 029 2240 4251

Email: [mathematics@wjec.co.uk](mailto:mathematics@wjec.co.uk)

Qualification webpage: <https://www.wjec.co.uk/qualifications/mathematics-a-as-level/>

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