Course report 2022

Subject	Mathematics of Mechanics
Level	Advanced Higher

This report provides information on candidates' performance. Teachers, lecturers and assessors may find it useful when preparing candidates for future assessment. The report is intended to be constructive and informative and to promote better understanding. It would be helpful to read this report in conjunction with the published assessment documents and marking instructions.

The statistics used in this report have been compiled before the completion of any appeals.

Grade boundary and statistical information

Statistical information: update on courses

Number of resulted entries in 2022	275

Statistical information: performance of candidates

Distribution of course awards including grade boundaries

A	Percentage	50.7	Cumulative percentage	50.7	Number of candidates	140	Minimum mark required	63
B	Percentage	15.2	Cumulative percentage	65.9	Number of candidates	40	Minimum mark required	54
C	Percentage	13.8	Cumulative percentage	79.7	Number of candidates	40	Minimum mark required	45
D	Percentage	8.3	Cumulative percentage	88.0	Number of candidates	25	Minimum mark required	36
No award	Percentage	12.0	Cumulative percentage	N/A	Number of candidates	35	Minimum mark required	N/A

You can read the general commentary on grade boundaries in appendix 1 of this report.

In this report:

- ‘most’ means greater than 70%
- ‘many’ means 50% to 69%
- ‘some’ means 25% to 49%
- ‘a few’ means less than 25%

You can find more statistical reports on the statistics page of SQA’s website.

Section 1: comments on the assessment

Question paper

The 2022 Mathematics of Mechanics question paper was modified as detailed in the National Course modifications summary. It consisted of 16 questions, the content of which was spread across all three sections of the course specification. The first nine questions were intended to assess some of the basic skills. The remaining seven questions often involved a greater depth of thought and problem-solving ability. These questions were, however, designed to be structured to allow all candidates to access at least some of the marks.

Overall, the paper performed as expected with most candidates attempting to answer every question. There were also far fewer instances of candidates providing no response to individual questions, which was taken into account when setting the grade boundaries.

Section 2: comments on candidate performance

Question 1(a)	Impulse and change in momentum were done well.
Question 1(b)	The entirety of question 1 was intended to provide a straightforward start to the paper, so it was very surprising to see so many candidates making basic errors in part b regarding the directions of the velocities. Essentially, they did not understand that the lack of a loss of energy made the velocities equal in magnitude but opposite in sign.
Question 2	Partial fractions with a repeated linear factor in the denominator were done well. However, where mistakes were made it was often because candidates did not know the correct form for the partial fractions.
Question 3	Projectile motion, finding maximum height and horizontal displacement were done well. Various equally valid methods were used for projectile motion.
Question 4	Simple harmonic motion was done well — finding period and amplitude.
Question 5	Solving a second order differential equation in a mechanics context. This was very well attempted, and it was pleasing that (unlike in previous years) very few candidates made mistakes related to the variables being x and t rather than y and x.
Question 6	Deriving the equations of motion for constant acceleration. It has been a number of years since this type of question has been asked but candidates coped well. Where marks were lost, they were often for not finding the constant of integration.
Question 7	Integration by parts was done well.
Question 8	Basic horizontal circular motion. This question was included because recent horizontal circular motion questions had produced disappointing responses. Therefore, it was pleasing to see responses to this basic theory question demonstrate solid understanding.
Question 9	Volume of revolution with integration by substitution. Candidates lost marks for subtle details such as limits changing with the change in variable.
Question 10(a)	Conservation of energy in a vertical circular motion context. Most candidates found this simple energy calculation to be straightforward.
Question 10(b)/(c)	Vertical circular motion questions often prove to be difficult because of the level of algebraic manipulation involved to combine the conservation of energy with resolving forces tangentially (this was the root of most problems in answering part c). In this case, candidates who may have been more familiar with string or hollow cylinder questions proved less comfortable with the rod. This fundamentally changes what happens to the mass in the motion, particularly as in this case when there is a zero or negative tension. Many candidates could not explain what their calculated negative tension meant so did not gain the final mark in part b.
Question 11	Solving a first order differential equation with an integrating factor was done well.
Question 12(a)/(b)	Whilst the responses to this question showed improvements in the standard of resolving forces on a slope (as per recommendations in

	previous course reports, for example 2019), this is still the source of many lost marks. It should be noted however, that the force being at an angle to the slope rather than parallel to it or horizontal, did add an extra layer of difficulty, as did the algebraic nature of the required answer to part (a).
Question 13(a)	Differentiating a quotient involving trigonometric functions was done well.
Question 13(b)	This question required a high level of reasoning to recognise that rearranging the equation given in part (a) produced a simple way to integrate the expression via a standard result from the course specification. Candidates who noticed this tended to be awarded full marks. Forgetting the constant of integration, however, was a common error.
Question 14(a)	Using calculus to calculate displacement at maximum acceleration was done well.
Question 14(b)	Calculating work done and using the work/energy principle when the force is variable, can often catch out candidates who proceed with a method based on the assumption that the force was constant resulting in them not using calculus. This proved less common this year but serves as a reminder that candidates need to be able to spot the difference between the two situations.
Question 15(a)	Resultant velocity with vectors. This first part of the question was attempted well via several equally valid methods.
Question 15(b)	The second part of this question was designed to be far more demanding and involved greater reasoning than any of the other questions. Drawing a diagram may have helped candidates to think through the path of the aircraft and what they were required to do, particularly in part (b)(ii).
Question 16(a)/(b)	Considering energy in the context of projectile motion. This question was at the end of the paper because of the unfamiliarity of these techniques in this context, but far fewer candidates than expected found this to be a problem.
Question 16(c)	This question was only worth 1 mark but proved to be very straightforward when the candidate recognised that, because this was projectile motion with no horizontal resistances, the horizontal component of the velocity remained constant and had already been stated explicitly in the question for part (b).

Section 3: preparing candidates for future assessment

The marking team was very positive in their praise for the overall performance of the cohort this year.

The areas in which candidates could improve are mostly things that have been raised before, rather than new issues, but they are worth reiterating.

- Good, clear diagrams would be helpful in many situations and would aid candidates' understanding, making the questions easier to interpret. The following topics (although this list is not exhaustive) fall into this category: resultant and relative motion, motion and equilibrium on a slope, vertical and horizontal circular motion.
- For all questions on a slope, the main reason for losing marks is not resolving forces correctly. This problem is linked to the one above. Candidates would benefit from more practice, particularly where friction is involved.
- Non-numeric questions, where candidates are asked to show or find an algebraic expression rather than a numeric answer. usually increase the likelihood of a poorer response. Candidates should be shown algebraic methods as a matter of course because it is very easy to adapt them to substitute values when required.
- It was clear in question 10 that some candidates had not come across questions on vertical circular motion involving a rod before. A variety of contexts for this topic such as strings, inside hollow cylinders, rods and outside spheres should be exemplified when teaching.
- Candidates who obtain a negative answer for a velocity, force etc (erroneously or not) should always explain what this negative answer means in the context of the question. Quite often we see candidates arriving at such an answer, then very clearly going back to try and 'fix' the negative instead of considering that this could be correct and, for example, could indicate a different direction.
- Whilst a lack of units is not something routinely penalised in this course, candidates should be encouraged to know and use units in every question where units are stated.
- Since the change to the instructions on the front cover of the question paper regarding rounding, it's pleasing to see that there are fewer instances of rounding being an issue. However, candidates should, as a rule, work with the non-rounded answers on their calculator wherever possible, and certainly use values in their working that have more degrees of accuracy than their final rounded answer. In general, candidates who round any final answer to only one significant figure, without stating a more accurate answer beforehand, run the risk of being penalised for a lack of accuracy.
- For indefinite integrals, candidates must be instructed to include a constant of integration. This is particularly important in integrating factor questions such as question 11 this year.

Appendix 1: general commentary on grade boundaries

SQA's main aim when setting grade boundaries is to be fair to candidates across all subjects and levels and maintain comparable standards across the years, even as arrangements evolve and change.

For most National Courses, SQA aims to set examinations and other external assessments and create marking instructions that allow:

- a competent candidate to score a minimum of 50% of the available marks (the notional grade C boundary)
- a well-prepared, very competent candidate to score at least 70% of the available marks (the notional grade A boundary)

It is very challenging to get the standard on target every year, in every subject at every level. Therefore, SQA holds a grade boundary meeting for each course to bring together all the information available (statistical and qualitative) and to make final decisions on grade boundaries based on this information. Members of SQA's Executive Management Team normally chair these meetings.

Principal assessors utilise their subject expertise to evaluate the performance of the assessment and propose suitable grade boundaries based on the full range of evidence. SQA can adjust the grade boundaries as a result of the discussion at these meetings. This allows the pass rate to be unaffected in circumstances where there is evidence that the question paper or other assessment has been more, or less, difficult than usual.

- The grade boundaries can be adjusted downwards if there is evidence that the question paper or other assessment has been more difficult than usual.
- The grade boundaries can be adjusted upwards if there is evidence that the question paper or other assessment has been less difficult than usual.
- Where levels of difficulty are comparable to previous years, similar grade boundaries are maintained.

Grade boundaries from question papers in the same subject at the same level tend to be marginally different year on year. This is because the specific questions, and the mix of questions, are different and this has an impact on candidate performance.

This year, a package of support measures including assessment modifications and revision support, was introduced to support candidates as they returned to formal national exams and other forms of external assessment. This was designed to address the ongoing disruption to learning and teaching that young people have experienced as a result of the COVID-19 pandemic. In addition, SQA adopted a more generous approach to grading for National 5, Higher and Advanced Higher courses than it would do in a normal exam year, to help ensure fairness for candidates while maintaining standards. This is in recognition of the fact that those preparing for and sitting exams have done so in very different circumstances from those who sat exams in 2019.

The key difference this year is that decisions about where the grade boundaries have been set have also been influenced, where necessary and where appropriate, by the unique circumstances in 2022. On a course-by-course basis, SQA has determined grade boundaries in a way that is fair to candidates, taking into account how the assessment (exams and coursework) has functioned and the impact of assessment modifications and revision support.

The grade boundaries used in 2022 relate to the specific experience of this year's cohort and should not be used by centres if these assessments are used in the future for exam preparation.

For full details of the approach please refer to the National Qualifications 2022 Awarding — Methodology Report.