AQA

# AS
# FURTHER MATHEMATICS

7366/2M: Paper 2 Mechanics
Report on the Examination

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**General**

This year, students showed more in-depth knowledge than in 2018 and were able to tackle all areas of the specification successfully. There were significant improvements in questions relating to dimensional analysis, energy and direct collisions. Students were able to gain more marks by using diagrams to help them to analyse the relevant situation, and apply the correct technique. The weakest areas proved to be those question parts where students were required to explain or give reasons, along with the topic areas of impulse and power with variable resistance. The quality of algebraic manipulation showed a distinct improvement this year.

**Question 1**

This question proved to be a very successful starter with around 88% of students choosing the correct answer. The incorrect answer that was most often chosen was $\frac{5\pi}{9}$, indicating that students thought there were $\pi$ radians in a full revolution rather than $2\pi$.

**Question 2**

This question also proved to be very successful with around 94% of students choosing the correct answer. The incorrect answer that was most often chosen was 4000 J, indicating that students simply multiplied 200 by 20, forgetting that part of the area was a triangle.

**Question 3**

Students demonstrated a good understanding of dimensional notation, and responses were greatly improved on last year. Almost all students knew that $\frac{1}{2}$ was dimensionless. The most common error was to use the incorrect dimensions for energy with several different incorrect expressions being seen. Two approaches were commonly and successfully used. These were:

- $[k] = \dfrac{\mathrm{ML^2T^{-2}}}{(\mathrm{L})^2} = \mathrm{MT^{-2}}$
- $[k] = \mathrm{M^{\alpha}L^{\beta}T^{\gamma}} \Rightarrow \mathrm{ML^2T^{-2}} = \mathrm{M^{\alpha}L^{\beta}T^{\gamma}} \times \mathrm{L^2} \Rightarrow \alpha = 1,\ \beta = 0,\ \gamma = -2$

Note it is important to use the conventional notation here when considering dimensions, because the question specifically asks for the use of dimensional analysis – any student using standard units would at best score 1 mark.

**Question 4**

This question proved more challenging than the corresponding circular motion question from last year, especially parts (a) and (c). In part (a) there was a lack of understanding about the relationship between the friction and Stephi's weight, with an incorrect or often no force diagram drawn. It was a common misconception to think that friction was 490 N, as it was half of 980 N. Very few fully correct force diagrams were seen, although there was no penalty on this occasion for not including the horizontal normal reaction, $R$, of 980 N.

In part (b) students demonstrated a clear understanding of the formula $R = mr\omega^2$ or $R = \dfrac{mv^2}{r}$ .

Some students failed to gain marks by:

- using the incorrect value for $R$ : more often 490N rather than 980N.
- incorrectly rearranging to make $\omega$ the subject.

In part (c) many students scored 1 mark for stating that either:

- Stephi was modelled as a particle
- air resistance had been ignored
- the radius was fixed at 4.6 m.

However many then failed to follow this with an appropriate explanation regarding this assumption. Respectively for example:

- her centre of mass is exactly at a distance of 4.6 m from the centre of the circle
- there is no need to consider any horizontal frictional force
- there is no need to consider variations in the value of the radius.

Gaining 2 marks was rare, although some students did display excellent understanding and commented appropriately using comments similar to the above.

**Question 5**

This topic was tested for the first time in depth this year and responses varied quite considerably; well over a third of students scored 6 or 7 marks. All students were aware of the $P = Fv$ formula and often used it correctly. When students scored 6 marks, it was often as a result of failing to explain that at the maximum speed the driving force equals the resistance — necessary to score the E1 mark and flagged up by the phrase 'Fully justify your solution' in the question. A handful of students failed to gain the final mark for not stating units.

The least effective responses were characterised by not using the $kv$ resistance force correctly and therefore scored very few marks. Other common errors were to use the same driving force of 1200 N for speeds of 40 m $s^{-1}$ and 25 m $s^{-1}$ and confusing driving force with resultant force in the equation of motion when the speed was 25 m $s^{-1}$.

**Question 6**

In part (a), students were able to demonstrate their understanding of different types of energy, with many successfully obtaining the correct answer. When mistakes were made, it was usually because of not using the correct vertical height for potential energy or nor resolving the distance correctly. A few students added all three values together or forgot to subtract the 500 J.

Part (b) was very successful, although to score both marks students needed to obtain a value that was subsequently rounded to 270 N to two significant figures.

Very few students scored all three marks in part (c). Many students chose to find the total energy required to move from *B* to *C* which was 540 J and then to compare this with the 500 J that Martin has at *B*, deducing that he would not reach the end of the slide. Others used energy or constant acceleration equations to find how far Martin would travel before coming to rest (1.85 m or 1.86 m) and then compared this to 2 m, deducing that he would not reach the end. However, in both cases the final mark could only be awarded if reference was made back to Martin being modelled as a particle, when he would not reach the end, or stating that he would likely reach the end as in reality he had size. Students should be aware that when questions use ‘Determine…’ it is very likely there needs to be a reflection on the assumptions used to score full marks. A small number of students provided thorough answers and did score full marks.

**Question 7**

The principle of conservation of momentum and the law of restitution were clearly familiar and there was a distinct improvement in students’ solutions this year. Part (a)(i) showed that conservation of momentum is well understood and virtually all students scored both marks for a correctly formed equation. Newton’s law of restitution was often applied correctly and consistently, with only a very few students reversing the correct formula or using momentum rather than speed. Many were then able to correctly answer (a)(ii), with errors rarely made, other than when expanding brackets or collecting terms.

Part (b) required an appreciation of the range of values for $e$ and, unlike last year, this was well understood and just over half of students scored 2 marks in this section. However, there did need to be clear reference to which expression for speed related to $e = 0$ and which to $e = 1$

In part (c)(i) many students were able to quote the relevant formula for impulse and to substitute corresponding expressions for velocities, however some failed to gain marks by mismatching masses and velocities. A lot of students did not see how to use the value of $e = 1$ to obtain the correct answer, with some choosing $e = 0$ instead or leaving $e$ in their final expression. Almost all students appreciated that ‘magnitude’ required a positive answer.

Part (c)(ii) was correctly answered by just over a quarter of students; it simply needed a statement that impulse was ‘equal in magnitude and opposite in direction’. A significant number of students talked about forces rather than impulse, stating that the impulse was zero as one sphere was stationary or that the impulse was less as the sphere was smaller. This showed some misconceptions about the nature of impulse between colliding objects.

## Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.