AS
FURTHER MATHEMATICS

Paper 2 – Mechanics
Report on the Examination

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General

Students showed varying knowledge across different areas of the specification. The topic areas where students were most successful were power, dimensional analysis, direct collisions, circular motion and impulse of a variable force. Students were often let down by a lack of diagrams which would have helped to analyse the relevant situation, for example in energy or collisions questions. The weakest areas proved to be impulse (constant), use of the maximum and minimum values of e and aspects of energy. The quality of algebraic manipulation was variable.

Question 1

This question proved to be a successful starter with 68% of students choosing the correct answer. The incorrect answer that was most often chosen was $\begin{bmatrix} 0.5 \\ 1.5 \end{bmatrix}$, indicating that students had forgotten to divide by the combined mass.

Question 2

This question was very successfully answered, with 94% of students choosing the correct answer. No student chose 90 m s^{-1}, whilst the other two incorrect options were chosen equally often by the remaining students.

Question 3

Although students demonstrated a good understanding of dimensional notation, this question proved to be more challenging than expected, with a mean mark of 62% for part (a) and 59% for part (b).

In part (a) a number of students did not appear to know that $\frac{1}{2}$ was dimensionless. In addition, whilst many students knew the correct dimensions for energy, the dimensions of ω were often incorrectly stated.

In part (b), the majority of students were able to start with the correct line $\left[I^{\alpha}W^{\beta}h^{\gamma}\right]=\left(\mathrm{ML}^{2}\right)^{\alpha}(\mathrm{MLT}^{-2})^{\beta}(\mathrm{L})^{\gamma}$ but often did not then collect terms together correctly or subsequently failed to form three correct equations. The most successful students here always clearly stated their three equations before solving.

Question 4

Parts of this question proved to be the most challenging on the paper, with mean marks of 59%, 47%, 13% and 32% for (a), (b), (c) and (d) respectively.

The concepts of conservation of momentum and the law of restitution were clearly familiar concepts but students made errors through lack of useful, clearly labelled diagrams. In the best solutions, students drew a diagram and labelled velocities clearly. Where labelling was not clear, it became apparent that students had confused themselves, and their momentum and restitution equations were not consistent with directions. Many students were unable to justify the printed answer for speed if they had obtained an answer of $\frac{u(2e-3)}{5}$ first.

Almost all students were able to score at least 1 mark in (b), with the most common error being in substituting the expression for speed rather than velocity.

Part (c) required an appreciation of the range of values for e in order to justify the directions of motion of the two smooth spheres. Many students failed to offer any justification and scored zero marks.

For part (d) many students were able to quote the relevant formula for impulse and to substitute corresponding expressions for velocities, but sign errors limited the number of marks available. The final result could then be obtained by considering limiting values for e. A significant number of students did not attempt this part at all.

Question 5

Students demonstrated a good understanding of circular motion and the associated forces. The mean mark for part (a) was 66% and the mean mark for part (b) was 69%.

In part (a) students demonstrated a clear understanding of the formula $\mathbf{F} = \frac{mv^2}{r}$. Marks were subsequently lost either by using the incorrect value for friction — either 9200 N or an average of the two stated values — or incorrectly converting speed from metres per second. It is well worth students thinking about how reasonable their final answer is to pinpoint any errors; for example speeds of 40000 mph or 0.5 mph are clearly not valid.

In part (b) the best answers clearly stated than 'wet conditions reduce friction' and that 'Gary's assumption was wrong as the upper limit had increased'. For both marks to be awarded, students needed to explain why the friction values should have been reduced and highlight the fact that the upper limit had increased in the proposed model.

Question 6

In this question, students appeared to have a better understanding of variable impulse that constant impulse. The mean mark for part (a) was 51%, the mean mark for (b)(i) was 69% and the mean mark for (b)(ii) was 36%.

Roughly half of all students obtained full marks for part (a) with the most common issue being a sign error. Students who did not appreciate the need to use opposite signs to calculate the required impulse scored zero marks. It was common to see 250(1.2) – 250(1.8) = –150, which scored zero marks.

Any error in part (a) was followed through, and many students did score full marks on the remaining parts. Part (b) was the most successfully answered, with students using their calculators to obtain a value of $\frac{32}{75}$ for $\int_0^{0.8} t(4-5t)\,\mathrm{d}t$ and hence find their value for k by using their answer from part (a).

Part (c) required students to appreciate that the model for the force was based on a quadratic function and hence to deduce that the maximum value occurred at $t = 0.4$. Many students left this part unanswered.

Question 7

In this question, students were able to demonstrate their understanding of principles of energy shown by a variety of correct approaches in part (b). The best approaches had clearly labelled diagrams which helped students obtain correct and consistent expressions for different types of energies. The mean mark for part (a) was 51%, the mean mark for (b) was 43% and the mean mark for (c) was 19%.

Part (a) was meant to be a simple application of conservation of energy when the cord reached its natural length. Many students applied the formulae correctly but did not give the final answer to two significant figures, thus losing the final mark. Required accuracy should match the value of g given in the question. A less common error was to use the height of the bridge above the river rather than the 25 m required.

There were many different approaches to part (b) and if students had used diagrams they would have been less confused and obtained more marks. The approaches seen were:

- calculation of the initial total energy (36750 J) and to compare this with the energy required for Dominic to reach the river (40000 J), deducing that there was insufficient energy to do so
- forming an energy equation and attempting to find the speed of Dominic at the surface of the river, deducing that he did not reach the river as v^2 was negative
- using x as the maximum extension, forming an energy equation to deduce that $x = 23.6$ m, deducing that Dominic would stop 1.4 m above the river and not get wet
- using x as the maximum length, forming an energy equation to deduce that $x = 48.6$ m, deducing that Dominic would stop 1.4 m above the river and not get wet
- using x as the minimum distance above the river, forming an energy equation to deduce that $x = 1.4$ m deducing that Dominic would not get wet.

All these methods proved to be successful for some students. However, without clear diagrams other students often got confused about what they were finding, leading to incorrect combinations of the different types of energies. Sometimes an x that had started out as a maximum length became an extension instead.

Part (c) linked to part (b) and required students to realise that if Dominic was not a particle then he would have height and hence could get wet if he was taller than 1.4 m. Any reference to air resistance here scored zero marks.

Mark Ranges and Award of Grades

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