Examiners' Report

Principal Examiner Feedback

Summer 2019

Pearson Edexcel GCE AS Mathematics

In Further Mechanics 1 (9FM0/3C)

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General

There were some candidates for this paper who clearly had a very good understanding of the material studied. The best work included clear diagrams, with structured working that was easy to follow.

There were a large number of candidates who could reach the given answers, but they were less confident in applying their knowledge when there was no given target – thy could apply basic principles such as the conservation of momentum and the impact law, but were then uncertain about what to do with the results. Some weaker candidates were not comfortable working with vectors.

It is difficult to be certain whether candidates were short of time or whether Q7 was as challenging as the responses suggest. It could be the case that candidates were not confident with Hooke’s law and elastic potential energy. There were several blank responses or rushed solutions with no clear method used.

The rubric to this papers tells candidates that if they need to substitute a value for *g* then they should use $g = 9.8$ and then give their final answer to 2 significant figures or 3 significant figures. Several candidates lost accuracy marks due to overspecified final answers or the clear use of $g = 9.81$.

Question 1

(a) The majority of candidates scored the first two marks for correct statements of the speed of the particle after its impact with each wall. Many went on to form a correct equation for the total time taken and reach the given answer. Some candidates made errors in the use of $\text{time} = \dfrac{\text{distance}}{\text{speed}}$ and some went wrong because they tried to use the average speed.

(b) The candidates used a variety of approaches to determine the least possible value of *T*. Some simply argued that they needed to minimise the numerator of the given fraction, some drew a sketch of the function, and some tried to use calculus. Many did reach a correct conclusion, but a significant minority did not.

Question 2

(a) The majority of candidates understood that they needed to consider components of the velocity parallel and perpendicular to the wall, and there were many correct solutions. The question is a “show that…” question, so it was not sufficient to quote $e \tan\alpha = \tan\beta$ without explaining where the result comes from.

(b) Some candidates made this more complicated than necessary by expressing the angles in degrees and finding the speed of the particle immediately after its impact with *AB*. Those candidates who used $\sin\alpha$ and $\cos\alpha$ and the two coefficients of restitution, working with components parallel and perpendicular to the walls, had quite simple calculations to complete.

(c) Many candidates showed a good understanding of the factors that could affect the final speed of the particle. Candidates should think carefully about the suggestions they put forward, and not simply write down anything that they have ever heard of being relevant in this type of question. Some of the suggestions made were irrelevant (such as the accuracy of *g*), and some were just incorrect.

Question 3

The unstructured nature of this question proved quite challenging for many candidates. Most could make a start and get some credit by forming an impulse-momentum equation, but this equation was often a mixture of scalars and vectors and led nowhere. Some candidates wrote equations in which they confused impulses and velocities.

A significant number of candidates did make the key step of realising that if the path of *P* had been deflected through an angle of $45°$ then the velocity must be parallel to **i** or parallel to **j**. Without this, some candidates did succeed in using a scalar product approach, although this sometimes resulted in complicated algebra with no conclusion.

Of those candidates who successfully found a set of values for λ and μ, many only got two pairs - either by symmetry or by considering the positive and negative square root - and a few of those who found all four erroneously excluded those with two negative components as not valid.

A small number of successful candidates used quite creative approaches including short intuitive insights to derive the four pairs from simple initial equations.

Question 4

The three parts of this question were independent of each other; candidates' scores seemed to follow a pattern of all four marks or zero marks in each part.

(a) The given answer resulted in many fully correct solutions. Some candidates formed separate equations of motion for the car and the trailer, and had to combine these in order to answer the question. A small number of candidates stated different components and correct expressions for the different terms of the equation of motion but never combined these in an equation, so gained only the first mark, despite declaring that $\lambda = 8$. The most common error was to overlook the constant speed and assume a non-zero value for the acceleration in the equation of motion.

(b) There was some confusion here over what needed to be considered; some candidates formed an equation for the car and the trailer moving up the road, and some considered only the trailer. Those candidates who considered only the car often reached the correct answer – their most common errors were a sign error in the equation of motion or using the resistance to the motion of the trailer in place of the resistance to motion of the car. The working involves the use of a substitution for *g*, so the final answer should be given to either 2 or 3 significant figures.

(c) This question specifically asked candidates to use the work-energy principle, so solutions reliant on an equation of motion and *suvat* equations scored no marks. Many candidates considering only the motion of the car gave fully correct solutions. Some solutions included the trailer, and some solutions double counted the gain in gravitational potential energy. Some candidates used the distance along the road, rather than the change in vertical height, when finding the change in potential energy. Some solutions omitted the work done against the resistance. A few candidates lost the final mark through giving an answer to more than 3 significant figures.

Question 5

(a) The majority of candidates scored the first four marks here, with correct use of the conservation of momentum, and correct use of the impact law. Some candidates stopped at that point, but most went on to find an expression for the velocity of P or the velocity of Q. At this point, candidates who had taken the time to draw a clear diagram showing the directions of motion of the two particles were able to form a correct inequality and deduce a corresponding range of values for e. Candidates without a diagram were more likely to state an incorrect inequality, but some candidates with a diagram contradicted their diagram. Only a minority of candidates went on to consider the direction of motion of the second particle and complete their solution.

(b) Many candidates with a correct expression for the speed of Q formed a correct equation for the loss in kinetic energy and reached the correct answer. The most common errors were to form an equation about the total kinetic energy lost (for both particles), or to use the percentage loss incorrectly.

Question 6

(a) Many candidates had clearly seen questions like this as part of their preparation for the exam, and they gave clear, confident responses. The question asks for the velocity of A. Several candidates found the speed without ever stating the velocity, and did not state the direction of motion. The final answer $\mathbf{v}_A = \frac{11}{3}\mathbf{i} + 2\mathbf{j}$ was quite common when candidates had all the correct working but did not take account of directions. A minority of candidates made the working unnecessarily complicated by working with speeds and angles. A small number of candidates worked with the line of centres of the spheres parallel to $\mathbf{j}$.

(b) Those candidates who worked with the velocities in vector form usually obtained the correct value for the magnitude of the impulse. The most common errors were due to working with speeds, or not giving the final answer as a positive number.

(c) Those candidates who worked with the scalar product usually obtained the correct answer, although some mistakenly thought they were looking for an acute angle and therefore used $|\cos\theta|$. Candidates working with a diagram had a clear advantage if they were using trigonometry to find the change in the two directions - the incorrect answer $62°$ was quite common.

Question 7

(a) The majority of candidates recognised that they needed to use energy. Many candidates initially treated the spring as a string and omitted the second term for elastic potential energy, but the given answer helped then to realise their error and correct their working. A significant minority of candidates showed completely correct working but in terms of λ and never used kmg, so they did not reach the given conclusion

(b) Many candidates formed the equation of motion correctly and obtained the correct answer. The question makes it clear that an answer in terms of g is required, but some candidates combined this with a decimal rather than working in fractions. The most common error was to forget to include the weight in the equation of motion – an answer of $\frac{8g}{7}$ was quite common.

(c) This question proved to be quite challenging. A significant number of candidates did not realise that the greatest speed would be at the equilibrium position, with many assuming that it was when the spring was at its natural length, or with an extension of $\frac{a}{2}$. For those candidates who were looking in the right place, it was common for one of the EPE terms to be missing in the energy equation. Some candidates had sign errors in their equations, and for some the algebra and fractions proved too much. A significant number of candidates did reach the correct final answer, many giving the answer in an exact form.

A few candidates started by forming the energy equation at a general point and proceeded to rearrange this to give an equation for v^2 in terms of x and then differentiate this and solve to find the value of x to minimise v; this was sometimes successful.

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