Examiners' Report

Principal Examiner Feedback

October 2020

Pearson Edexcel GCE Advanced Level

in Further Mathematics

Paper 3C: Mechanics 1 (9FM0/3C)

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The relatively small number of candidates sitting this paper showed a wide range of abilities. There were some candidates who demonstrated a strong understanding of the topics examined, attempted all the questions and presented clear well-argued responses. Other candidates seemed to be targeting particular topics, and those who were not confident in working with vectors struggled with several of the questions.

Several candidates lost marks through not paying sufficient attention to the precise demands of the questions.

Question 1

(a) The majority of candidates recognised the need to form an impulse-momentum equation, and many did succeed in finding the magnitude of the impulse correctly. Some candidates found a correct expression for the impulse but did not go on to find the magnitude. There were some slips in the arithmetic and a significant minority of candidates used speeds rather than velocities in their attempt to find the impulse.

(b) The simplest way to find the required angle was to use the scalar product, but several candidates had success using alternative methods. Most errors were due to finding the angle between the wrong pair of vectors.

Question 2

(a) The majority of candidates formed a correct equation for the motion of the truck. They found a negative value for the acceleration of the particle but often did not go on to conclude that the deceleration was positive.

(b) Most candidates formed an equation of motion containing all the required terms. There were some sign errors, and some candidates did not include a component of the weight. The majority of candidates who formed a correct equation went on to find the correct solution. A few candidates gave their final answer to more than three significant figures, which is not appropriate following the use of 9.8.

Question 3

(a) The majority of candidates used conservation of momentum and the impact law correctly. There were several slips in the algebra, but many obtained correct expressions for the speeds of the two particles after the collision. The final mark required candidates to use the known range of possible values for e to demonstrate that the particles would continue moving in the same direction. Some arguments were incorrect, and some lacked clarity.

(b) Most candidates started with a correct attempt to find the speed of *B* after the collision with *C*. In order to confirm that there will be a second collision between *A* and *B* it is necessary to demonstrate that, for all values of *e*, the speed of *A* after the first collision is greater that the speed of *B* after the second collision. Many candidates simply substituted values for *e* and did not consider the behaviour of the quadratic function in *e* over the full range of possibilities.

Question 4

(a) There are several ways to tackle this question, some more succinct than others. The simplest approach is to find the impulse acting on the ball and then form the scalar product with $2\mathbf{i}+3\mathbf{j}$ to show that the impulse is perpendicular to $2\mathbf{i}+3\mathbf{j}$. Several candidates spent time and effort trying to find angles and components of the initial and final velocity; some of these methods were successful.

(b) In this part the candidates need to consider the components of the velocity perpendicular to the wall. Use of the scalar product gives a simple and accurate way of solving the problem, but those candidates who had found the correct angles in part (a) were able to use their answers here. Candidates using the angles were more likely to make accuracy errors due to premature approximation.

Question 5

(a) Those candidates who started with a diagram with the correct line of centres clearly marked were most likely to reach correct conclusions. Many candidates did form correct equations for conservation of momentum and for the impact law working parallel to the line of centres, but there were several candidates who wrote down equations in two dimensions. Some candidates wrote down an equation for the combined kinetic energy of *P* and *Q*, but the information given relates only to *Q*. The simplest way to solve the resulting simultaneous equations is to use the kinetic energy equation to find the velocity of *Q* and then use the other two equations. Candidates who started by finding the components of the speeds of *P* and *Q* in terms of *e* had more complicated algebra to deal with. The reason for the question asking the candidates to "carefully justify" their answers is that there are two possible solutions to the equations, one of which is not possible. In order to gain the final mark, the candidates needed to say why the second solution was not possible - very few candidates scored this mark.

(b) Most candidates did attempt to find the angle between the velocity of *P* before the collision and the velocity of *P* after the collision. Working in vectors was the simplest approach but not the only possible approach.

Question 6

(a) Most candidates recognised the need to use conservation of energy. The work done against friction and the gain in gravitational potential energy were usually found correctly. Some candidates used $3l$ for the extension of the string, rather than $2l$, to calculate the elastic potential energy in the string when the package is at B. There were many fully correct work-energy equations. The most common errors were sign errors, incorrect elastic potential energy and double counting the work done against the weight and the gain in gravitational potential energy. There were some attempts to solve the problem using *suvat* formulae, which are not appropriate here because the acceleration is not constant.

(b) Most candidates were able to use the given value for k to find an expression for the tension in the spring when the package is at B. Most errors were due to using an incorrect value for the extension in the string, terms missing from the equation of motion or sign errors in the equation.

Question 7

(a) This part of the question asked candidates to demonstrate a given result. This meant that they were required to start by considering the components of the velocity of the ball parallel and perpendicular to the wall for each collision. Some candidates did not earn full marks here because they did not work from first principles, starting instead from a remembered result about tangents of angles. The majority of candidates were able to use the formula for $\tan 2A$ to derive the given result.

(b) The majority of the errors in this part of the question were in the processing of the arithmetic: most candidates were able to form an expression for the kinetic energy lost and to express this as a percentage of the initial kinetic energy of the ball.