Examiner's Report
Principal Examiner Feedback

Summer 2018

Pearson Edexcel GCE
In Mechanics M2 (6678/01)

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Introduction

This paper proved to be accessible to students at all levels, and most students offered solutions to all seven questions. The stronger students scored close to full marks for the first four questions. The weaker students found that parts of most questions were straightforward.

The best solutions were clearly set out, accompanied by clear labelled diagrams, and a commentary about what the student was doing at each step. Some solutions have little or no commentary which often makes it difficult to follow the logic; this was particularly evident in the second part of question 5. In those questions where the answer is given, it is particularly important to give full and clear working.

There are still several students whose writing is close to illegible partially due to very small writing and in some cases due to the use of what appear to be felt-tipped pens.

Some students overwrite pencil working in ink and some erase a solution and write over it. When the work is scanned, both of these actions result in a solution that is barely legible. If a solution is incorrect, put a line through it and start again.

Accuracy marks are often lost because the student does not follow a specific request in a question regarding accuracy for the answer to that question, or they do not follow the instructions in the rubric for the paper regarding the use of a substitution for g.

Question 1

(a) This part of the question provided most students with a friendly start to the paper, and many scored full marks. Most students resolved correctly to form an equation of motion involving all three terms, but there were several sign errors. Some students had not noted that the truck was moving down the road, so they had the driving force and the weight acting in opposite directions.

(b) Many students scored full marks for this part of the question. Here again, the main difficulty was to get the signs correct in the equation of motion. Several students did not score the final mark because the accuracy of their final answer was inappropriate following the use of an approximate value for g - some answers were given as decimals with too many significant figures, and some as exact fractions.

Question 2

The response to this question was very varied. There were many fully correct solutions, but also a significant number of students who only considered the component of the impulse parallel to the original direction of motion. It should have been clear from the diagram that there had been a change both parallel and perpendicular to the original direction of motion.

(a)Those students working in two dimensions showed a good understanding of the methods to use here. There were a few errors with confusion between sine and cosine, but most students wrote a complete equation in vector notation. A few students preferred to write out each component separately.
There were several accuracy errors due to premature rounding of the components (which affected the answers to both parts of the question).

(b) A few students found the required angle using a vector triangle, but the majority found the tangent of the angle using their components from part (a). A significant minority of students went on to subtract the correct answer from $90°$ or$180°$ to obtain an incorrect final answer - this amounted to not having a correct strategy for the required angle and only one of the three marks was scored.

Question 3

(a) A small number of students ignored the information given at the start of the question and found the position of the centre of mass of the semicircle using the formula for centre of mass of a sector - usually correctly. Many students did obtain the given answer correctly - some made the working more complicated than necessary by working from a horizontal axis other than *BD*, but they usually subtracted correctly to reach the distance required. The most common errors were sign errors in the moments equation, and use of an incorrect area for the semicircle.

(b) Many students gave a fully correct solution - very few failed to find the correct angle. A significant number of students did not score the final mark because they did not give their final answer correct to the nearest degree.

Question 4

This question was answered well by the majority of students; there were many simple and elegant solutions. By far the most common approach was to resolve horizontally and vertically, and then take moments about *A*. This led to a straightforward substitution and simplification. There were several alternative approaches, some requiring only two equations, for example taking moments about *B* and resolving parallel to the rod. Almost all students used $F = \mu R$ correctly.

Those students who wrote down more equations than necessary often got lost in the algebra and did not have a clear strategy for forming an equation in μ.

Since the question was a 'show that' question, a number of students who could not turn their equations into the required expression took to improvising the algebra and manipulating it to give the desired result. This usually resulted in the loss of the last three marks, and sometimes more if they went as far as altering what had originally been a correct set of equations for moments and resolving.

The method using three concurrent forces was not seen.

Question 5

(a) This was a standard collision problem and most students showed a high level of proficiency in answering it. With a given answer, those who had gone wrong at an early stage realised there was an error and had the opportunity to review their solution and remedy any mistake. As the answer is given, it was not appropriate to simply write down the simultaneous equations and use a calculator to find the solution.

(b) This part of the question was quite challenging for most students. However, several showed clear thinking and good problem-solving skills in producing complete solutions. There are a number of correct alternative approaches and all were seen. Most students started the solution sensibly, finding the time that *B* took to reach the wall and also the rebound speed of *B* after its collision with the wall. From that point there were many flawed strategies with times and distances becoming rather muddled and no coherent approach presented. All too often there was no commentary, which made it difficult to decipher what the student was attempting to do. Some students were not clear about the direction of motion of *A* after the first collision with *B*. As is commonly the case, a clear diagram was often a key part of a successful solution.
A few students showed very little understanding of the concept of motion with impact and motion on a smooth surface by attempting to relate *y* to the speed of *B* before and after its impact with the wall using equations such as $s = \frac{u+v}{2}t$.

Question 6

(a)(i) This was answered correctly by most students. There were a few slips in the arithmetic, but many students found the acceleration correctly and hence the magnitude of **F**. A small number of students found **F** correctly, but did not go on to find its magnitude. A few students substituted to find the velocity when $t = 3$, rather than the acceleration.

(a)(ii) This part of the question proved to be more challenging. A significant number of students did not associate the direction of motion of *P* with **v**. Some students tried to find the time when $\mathbf{v} = -\mathbf{i} - \mathbf{j}$ rather than look for the time when the components were equal. Those students who did adopt a correct strategy usually found the correct value for *t* (rejecting the possibility of a negative value). Several students went on to find the magnitude of the acceleration, which was not asked for.

(b) Most students scored some marks for this part of the question. Virtually all students realised that they needed to integrate, and did so successfully. Some included constants of integration, some limits and a few used both. A small minority of students used the limits the wrong way round, but most errors at this stage were arithmetic slips.

Question 7

(a) This is a standard question and proved to be very accessible, with most students achieving full marks with sufficient working shown to support the given answer. A small number of students had a sign error in the equation for vertical motion, and some were not clear in the final step when substituting a numerical value for $\cos^2\alpha$. Students need to be careful to provide full working in a "show that" question.

(b) The most straightforward way to tackle this part of the question was to use the result from part (a) and find the value of *u* for which $y = 0$ when $x = 36$. The more usual approach was to start afresh with the *suvat* equations and find the answer in two or more stages. This approach involved a number of slips in the arithmetic and algebra, resulting in several incorrect answers.

(c) The majority of students realised that the minimum speed was at the highest point of the path and used the horizontal component to achieve the correct answer for the minimum kinetic energy. A few students work with *u* rather than with the horizontal component of *u*, and a small number just assumed that the answer was zero.
Several students incurred an accuracy penalty by leaving the final answer as 13.23(J) rather than rounding to 2 or 3 s.f. following the use of $g = 9.8$.
(d) This part of the question proved to be very challenging. Few students adopted the first method on the mark scheme, to find the value of *x* for which the gradient of the trajectory is $-\frac{1}{2}$.

Only a minority of the students who attempted the question had a clear strategy involving the correct direction of motion. The most common approach was to determine the vertical velocity at *B*, use *suvat* to find the time to reach *B*, and then the horizontal distance. When seen, the scalar product approach was often successful.

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