Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

Summer 2024

Pearson Edexcel International Advanced Level
In Mechanics M2 (WME02)
Paper 01

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Summer 2024
Publications Code WME02_01_2406_ER

WME02 June 2024 – Report

Most questions on this paper would have been familiar to a candidate whose preparation had included work on past papers. Question 1 was a familiar topic presented slightly differently, but it contained a clear indication of how to proceed. In question 2, it is unusual for the speed/time relationship to be presented in two parts, but this format has been used in other situations and was clearly stated.

The work seen covered the full range of marks available, and the majority of candidates offered responses to all the questions. The best work included clearly labelled diagrams and clear explanations of what the candidate was trying to do. The lack of diagrams caused particular problems in questions where the candidates needed to be aware of the direction of forces or the direction of motion of an object.

In many responses there was insufficient attention to notation, which inevitably leads to errors. When choosing names for forces the intention was often not clear and the forces were not shown on any diagram. In question 6 the writing was often so unclear that the candidates themselves could not distinguish 2, a and α. There were also issues with missing brackets and square root signs failing to enclose a complete expression.

Many candidates used 9.8 instead of g when asked for an algebraic solution, then reinstated the g at the end. Some candidates continue to use $g = 9.81$ despite the clear instructions in the rubric and regular comments in these reports. The syllabus and the rubric to the paper are both very clear about the value of g that candidates are expected to use. If these instructions are not followed then candidates will lose accuracy marks. The safest approach is not to make any substitution until it is absolutely necessary.

Some candidates insist on cramming their answers into the smallest possible space. There is no shortage of space in the answer booklet, and minuscule script makes it very difficult for the examiner to follow the work.

Question 1

(a) Most candidates knew the correct expression for kinetic energy but a few were unsure on how to apply it to vectors. Some candidates forgot to square one or both of the velocities and some added the velocities before squaring. Some candidates confused the velocity of A after the collision with the velocity of A before the collision.

(b) There were many correct answers. There were some slips with the arithmetic. Most candidates did attempt to subtract velocities, but some subtracted the wrong way round. The question asks for an answer in terms of **i** and **j**, but some candidates used other formats.

(c) There were many correct solutions, although a significant number of candidates did not act on the clear hint in the question that the impulse on B acts in the opposite direction to the impulse on A. Most candidates did attempt to solve the problem by using an equation for impulse and momentum, but the alternative of using conservation of momentum was also seen.

Question 2

This question makes no mention of vectors but a large minority of candidates interpreted the two components of the function as being components parallel to vectors **i** and **j**. These candidates could score the marks for correct calculus, but the error had significantly changed the question so other marks were not available.

(a) The majority of candidates understood that they needed to equate the two expressions and solve the quadratic, rejecting the negative solution. Few however realised that explaining their method included an explanation of why they were rejecting the negative solution, so many candidates did not score the final mark. Some candidates verified that the two expressions were equal for $k = 4$, but this is not the same as showing that the value of k has to be 4.

(b) Most candidates differentiated the correct function for $t = 1.5$ and obtained the correct answer. Some candidates were confused by the nature of the function and differentiated both parts, occasionally giving two answers, and sometimes attempting to combine the two parts or to give the answer as a vector.

(c) Most candidates were able to integrate both parts of the function. It was not appropriate to use *suvat* for the interval $0 \leqslant t \leqslant 4$, but it was occasionally used correctly for $t > 4$. There was often confusion about which limits applied to which integral. The candidates who treated the question as a vector problem could score marks for correct integration.

Question 3

(a) The majority of candidates identified all the elements needed to form an equation for moments about an axis through X. The alternative of using the left-hand end of the diameter was also seen. Many candidates did not understand that the centre of mass of the template would be to the left of X, so they used kr rather than $-kr$ in their equation. This sign error resulted in a lot of unrewarded effort to try to obtain the given answer. Many of the candidates who started with a correct expression would have obtained the answer more quickly if they had recognised $R^2 - r^2$ as a difference of two squares.

(b) Most candidates used $0 < r < R$ correctly to obtain the correct answer.

(c) The candidates used a variety of routes through the algebra, but most did have a correct method to find the tangent of a relevant angle. It was common to see the angle between XY and the horizontal rather than XY and the vertical.

(d) The key to this problem is to identify where the additional particle should be placed. Those candidates who did this correctly usually obtained the correct answer. Candidates who decided that the mass of the additional particle was m often went on to confuse this with M. The candidates who tried to use moments about an axis other than the axis through P usually forgot to include the forces acting at P in their equation.

Question 4

(a) Almost all candidates obtained the given answer correctly. A small number with confusion between sine and cosine were able to identify and correct their error.

(b) Most candidates followed the instruction to use the work-energy principle. The two most common mistakes were a sign error or not including the length of *AB* when calculating the work done against friction. A small number of responses had a correct unsimplified equation but made a processing error in simplifying the equation.

(c) Some candidates did not realise that they also had to use the work-energy principle for this part of the question. They used *suvat* equations instead and scored no marks. Responses that did not include the length *AB* when calculating work done against friction in part (b) usually continued with the same error. The most common error was a sign error in the unsimplified work-energy equation. Responses with an incorrect value for *d* from part (b) were often able to gain credit for using their value correctly. Some candidates were careless in the use of the square root sign for the final mark – it is important to ensure that the sign clearly covers all the necessary terms.

Question 5

(a) The best solutions were accompanied by a diagram with the masses of the particles, and the velocities and their directions clearly indicated. There were many fully correct solutions, but also a significant minority of candidates who overlooked the information about the direction of motion of *P*. There were many sign errors in the equations, and also a few processing errors. A small minority of candidates used the impact law the wrong way round. There were also some candidates who found the velocity of *Q* and not the velocity of *P*.

(b) Very few candidates achieved full marks. Again, a diagram would have helped to avoid sign errors and using the wrong velocities. Most candidates were able to gain the B marks but without a diagram the inequality was sometimes the wrong way round or incorrect velocities were used. Very few candidates were able to gain the last mark, most using zero as the lower limit. Sign errors and manipulation errors were common.

Question 6

(a) Many candidates would have benefitted from a diagram with forces clearly labelled – the diagram given in the question could have been annotated with all the relevant information. Most successful candidates created an equation for moments about *A*. They were then able to resolve correctly to find the required answer.

Responses that used an equation for moments about *B* were usually successful but some of these responses did not include the frictional force acting at *A*.

A small number of responses created their equation using the angle between the floor and ladder. Most of these were able to find the value of $\tan\alpha$ successfully at the end.

Some responses had the reaction at *B* perpendicular to the rod rather than perpendicular to the wall. This was sometimes associated with a frictional force between the rod and the smooth wall.

Some responses were difficult to follow because candidates did not give a clear statement of what they were doing and what equations they were using.

(b) A clear diagram would have helped in this part too. Many candidates did not include sufficient working to justify their answers. The force at the wall was often not mentioned specifically and most of the candidates who realised that it would have the same value as in part (a) did not actually explain that this was because considering moments about *A* would lead to the same equation. There had to be some justification of the values used to score any marks.

A common mistake was to make a sign error in the horizontal resolution, not recognising that the direction of the frictional force would be reversed.

The candidates who considered moments about *B* often had one of the forces acting at *A* missing from their equation.

Question 7

(a) This was generally well answered with a variety of approaches used. The most popular method was the main one from the mark scheme although a sizeable number of responses used the time to the highest point of the motion and a horizontal distance of 40. Some candidates confused the horizontal and vertical components of the velocity – this led to the same answer of 14 so they would not have realised their error. Some candidates were clearly using $g = 9.81$ in their working.

(b) Most candidates had a correct strategy for finding the vertical component of the velocity or the height of the ball above the ground when the speed was equal to $7\sqrt{17}$. A large proportion gained no further marks because they found the time for which the speed was less than $7\sqrt{17}$ rather than the time for which the speed was greater than $7\sqrt{17}$. Very few had produced a quick sketch of the motion, which might have helped clarify what they needed to do. Several candidates left their final answer as 10/7, which is not appropriate following the substitution of a value for *g*.

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