Examiners' Report

January 2015

Pearson Edexcel International Advanced Level in Mechanics Mathematics M2 (WME02/01)

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General Comment

This paper allowed the candidates to demonstrate their understanding of mechanics; parts of all questions were accessible to all candidates, but there were also some marks that proved to be more challenging. Many candidates offered responses to all seven questions.

The majority of candidates appeared to be well prepared for the exam, showing a good knowledge of the whole syllabus. Some aspects, such as questions posed in vector format, proved to be more difficult. Candidates whose work included clear labelled diagrams were often the most successful. Similarly, those candidates who say what their equations represent often gain more credit than those candidates who leave the examiners guessing what they were trying to do.

Candidates should be reminded that "show that" type questions need unambiguous clarity to support the argument in order to score full marks. Those candidates who are very reliant on calculators need to check their working particularly carefully – an incorrect answer with no supporting working will score no marks. There were several instances of candidates losing marks because they did not give their answer in the form asked for in the question – if time permits it is always sensible to make sure that you have found what was asked for.

The rubric to this paper is very clear that, when substituting a value for g, candidates should be using 9.8. In particular, the use of 9.81 is treated as an accuracy error in each question where this occurs. After the use of g = 9.8 , answers should be given to either two or three significant figures.

Question 1

This was a straightforward opening question for many candidates. The initial impulse-momentum equation in part (a) was usually correct and the correct impulse was often seen. Some candidates did not go on to find the magnitude of the impulse, as requested by the question. Many candidates quoted the correct formula for the change in kinetic energy in part (b), but did not use it correctly. The error $\frac{1}{2}m(|\mathbf{u}|-|\mathbf{v}|)$ was quite common. Rather than working with the moduli of the velocity vectors, some candidates attempted to square the vectors by squaring their components and obtained a vector answer.

Question 2

The majority of candidates obtained full marks in part (a). Any errors were usually in the calculations rather than in forming correct equations. Several candidates were clearly using $g = 9.81$. In part (b) the majority of candidates did follow the instruction of the question and attempted to solve this part using work-energy, although several also tried a *suvat* approach to check their answer. Many candidates scored no marks, either due to a dimensionally incorrect energy equation (missing '*d*' from the work done) or to an energy term double-counted or missed out. Bizarrely perhaps, there were several solutions where the mass used was 500 in part (a), and then 0.6 in part (b) – presumably this was due to confusion between questions 1 and 2? There were also some scripts with the correct value $\sin\theta = \frac{1}{20}$ in part (a) but then $\sin\theta = \frac{1}{14}$ in part (b).

Question 3

The majority of candidates knew how to find the velocity and acceleration of the particle via differentiation. However quite a number, although often scoring full marks in parts (b) and (c) having differentiated at that point, scored no marks in part (a) where they did not recognise that the direction of motion is defined by the velocity and not the position vector. In part (b) several candidates left their answer as a vector, possibly not noticing that they had been asked for the speed rather than the velocity.

A surprising number of candidates who had the correct velocity $38\mathbf{j}$ went to great lengths to demonstrate the use of Pythagoras' theorem to find the magnitude and did not always get an answer of 38. There were many correct answers to part (c) – the candidates understood what was required and, with the exception of a few arithmetic errors, they worked through correctly. Many went on to find the magnitude of the acceleration, which was not required in this instance. Part (d) was a problem for some candidates. Most found $\mathbf{r}(0)$ and $\mathbf{r}(4)$ correctly but then many calculated $|\mathbf{r}(4)| - |\mathbf{r}(0)|$ rather than $|\mathbf{r}(4) - \mathbf{r}(0)|$. Some candidates overlooked the position vector given at the beginning of the question and used integration to work back from their acceleration to find the displacement.

Question 4

A significant number of candidates offered no response to this question or seemed to have no real awareness of how to start the question. It was not necessary to complete part (a) in order to be able to answer part (b) and some candidates did answer part (b) having given no answer to part (a). In part (a) candidates' methods ranged from the efficient, with a real insight into the problem and its geometrical properties, to the more laboured. The more efficient methods made use of $\frac{a + a\cos\theta}{2}$. Others used symmetry and worked with just one of the rhombuses. Many split the shape up and used two rhombuses, four triangles or a rectangle with triangles either added to or subtracted from their initial shape. Students who used some aspect of relative mass proved more successful than those who used complete expressions for area, which when combined with the centres of mass resulted in long and complicated equations. Students need to be encouraged to explain their work in greater detail - in particular it would be helpful if they could say which axis they were using when taking moments. The students who made use of $\cos\frac{\theta}{2}$ leading to $\cos^2\left(\frac{\theta}{2}\right)=0.9$ then had to deal with getting to $\cos\theta = 0.8$.

Students who had experience of double angles produced valid solutions but students who used calculators, resulting in non-exact methods, lost the last mark. With the final answer being given in the question it was not unusual for some creative statements to appear or an answer to suddenly appear. Those candidates who attempted part (b) were usually successful. Candidates who took moments about *A*, *B* or the centre of mass generally obtained the correct answer, although there were a few processing slips leading to an answer of 8 rather than 1/8. Students who took moments about *D* often omitted a term from their moments equation, resulting in an incomplete method and no marks.

Question 5

In part (a) many candidates gave correct answers. There were a few trig errors, and some slips in working, with *g* appearing and disappearing between lines, and $(1+2k)$ becoming $(1+k)$. In part(b) the majority of candidates attempted to resolve horizontally and vertically, as suggested by the demand in the question, but some candidates resolved parallel and perpendicular to the rod (while still claiming to be considering vertical and horizontal forces). Most candidates obtained correct unsimplified equations, but there were some errors in simplifying the expressions. In part (c) many candidates understood that they needed to set the horizontal component equal to the vertical component. Those who had assumed that the vertical component of the force acted downward when answering part (b) took no account of this once told that the resultant of the components acted upwards. The most common errors involved substituting $\theta = 45°$ or attempting to find an expression for the resultant of the two components.

Question 6

A significant number of candidates used conservation of energy to answer part (a), and most of them were successful. However, the most common approach was to combine the vertical and horizontal components of the velocity. Many correct answers were seen, but there were also a lot of accuracy errors, either giving an exact answer or an over-specified answer following the use of 9.8, or an answer of 15.6 due to a rounding error. The most common error was to calculate only the vertical component of the velocity and not consider the horizontal component. In part (b) candidates who had found the horizontal and vertical components of the velocity in part (a) were usually successful here. Some found the size of the angle correctly but gave no indication in words, or via a diagram, of the direction of motion. In part (c) many candidates applied *suvat* equations correctly to form and solve an equation for *t*.

A small number of candidates prefer to divide the motion into sections, finding the time to reach the maximum height and the time to drop - in this approach there were greater chances of losing marks through premature approximation of answers. There were some sign errors in forming the equation in *t*, but the most common problem was an incorrect solution to a quadratic equation with no method or working shown. Candidates should remember that they are expected to include adequate explanation of their method – if they show no method and simply give an incorrect answer to the quadratic equation directly from their calculators then they will score no marks.

Question 7

In part (a) most candidates were well prepared for the first apart of this question and tackled it with confidence. Their equations for conservation of momentum and for the impact law were invariably correctly structured, with just a few sign errors or confusion of the masses of the particles. There were some errors in solving the equations, but most candidates did not score the last mark in this part because they did not ensure that their answers were positive.

In part (b) most candidates used their expression for the velocity of P to form an inequality in e. but some did not recognise that this was where they needed to use the information about the direction of motion of P. In part (c) those candidates who used clearly labelled diagrams to keep track of the masses and velocities of the three particles had a clear advantage. Those who substituted $e = \frac{2}{3}$ at the start of their answer and simplified the algebra as they worked through were more successful in scoring full marks than those working in terms of e with no substitution or later substitution. Some candidates with correct working presented a flawed argument for the final mark, which requires consideration of both the direction of motion and the relative velocity to confirm a second collision.

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