Examiners' Report

Summer 2015

Pearson Edexcel GCE in Mechanics M2 (6678/01)

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Mathematics Unit Mechanics 2

Specification 6678/01

General Introduction

This paper offered all students the opportunity to demonstrate their understanding of mechanics. Most students offered solutions to all eight questions, but some clearly spent a lot of time on questions 2 and 4. In many cases, students with a clear understanding of the mechanics made numerical and algebraic slips before reaching a final answer. A full range of marks was seen, from clear concise work, usually accompanied by clearly labelled diagrams, to work which was poorly set out with inadequate commentary. Students should be reminded of the need to present legible work which the examiner can follow.

The accuracy of final answers continues to be an issue. Too many students confuse accurate working and the use of approximations and seem to move freely between the two. The rubric on the paper is very clear over what is expected after the use of $g = 9.8$ ms^{-2}, but students continue to give away marks with inappropriate final answers.

Report on Individual Questions

Question 1

This was a straightforward power question that was well answered, with many students scoring full marks. The most common error was to have the weight acting up the slope in the equation of motion, which suggests either a lack of basic understanding or a failure to read the question carefully. Some solutions revealed a poor choice of notation, using '*F*' to represent both the driving force and the resultant force.

Question 2

For many students this was a more straight forward question on centre of mass than some in recent papers.
(a) There was a range of valid approaches to this problem; splitting the shape into a rectangle and two triangles, or into three triangles or just looking at the trapezium obtained by halving the shape. However the most popular approach was to 'subtract' the top triangle from the square. Moments were taken about a variety of axes and the adjustment needed at the last step was well done by most students, however some did leave their final answer as $-\frac{2}{9}a$ and some made the negative sign vanish without explanation.

(b) Some students abandoned this part of the question after drawing several diagrams of the lamina in various positions.

The most successful students took moments about AC. The common error in this approach was to resolve one distance but not both. The alternative method of taking moments about a pair of perpendicular axes was common and often successful. Apart from algebraic errors, the most common error by this method was to assume that the centre of mass of the system was at the centre of the square rather than on the diagonal through A.

Question 3

(a) The majority of students used the impulse-momentum equation correctly, although some of the solutions were quite laboured. The incorrect form $\mathbf{I} = m\mathbf{u} - m\mathbf{v}$ was a common error, but most errors at this stage were in dividing by 0.75.
Some students used scalar product to find the angle between the two velocities, but the majority used $\tan^{-1}\left(\frac{8}{12}\right)$. Several students went on to subtract the

required angle from 180°, suggesting some confusion about the angle between the two vectors.

(b) Many students answered this correctly. Most students were able to find a difference between the kinetic energy terms with the majority of students correctly finding the magnitude of their velocity vector. The most common error was to find the magnitude of the change in momentum (using v rather than v^2), but the incorrect form $\frac{1}{2}m(v-u)^2$ was also quite common.

Question 4

This was a straightforward question testing a basic understanding of ladders. Many students produced a correct moments equation, usually about A but occasionally about B. The question gives $\tan\theta = \frac{5}{3}$, which gives awkward values for $\cos\theta$ and $\sin\theta$. Several students divided by $\cos\theta$ so that they could substitute directly for $\tan\theta$ - this makes the resulting equations easier to work with. Seeing 3 and 5 led some students to the incorrect assumption that they were working with a 3, 4, 5 triangle. Other common errors included having the friction force on the wall acting downwards rather than upwards, making a sign or trig error in the moments equation, multiplying W by g, and processing the equations inaccurately

Although there were many clear and concise solutions to this question, students could help themselves (and the examiners!) by adopting logical labelling of forces such as R_A, F_A, R_B, F_B or by limiting themselves to two forces and using R, μR, N, $\mu' N$.

Question 5

(a) There were many correct answers to this part of the question. The method for finding the work done against the friction was well understood, but some students also included the gain in gravitational potential energy in their answer. In the course of the working an approximate value for g is used, so an "exact" answer of $\frac{5}{12}$ is inadmissible.

(b) The majority of students followed the request to answer this using the work-energy principle. There were many correct answers. Common errors involved sign errors in the work-energy equation, or omitting a term (often the work done against friction) from the equation. As the question specifies the method to be used, attempts to answer the question using *suvat* equations scored no marks.

Question 6

The methods required here were well understood, and almost all students scored full marks in part (a) and in part (b).

Most students started part (c) with correct integration of the velocity to find a formula for distance. Many did not follow the hint from part (a) about the change in direction of motion at the instants when *P* is instantaneously at rest, so they found the displacement from *O*, rather than the distance travelled. Those students who did split their solution into three correct integrals often made numerical slips before reaching the final answer.

Question 7

(a) The response to this question was very varied. A significant minority of students offered no response at all. Those students who set out clear equations for the horizontal and vertical components of velocity usually went on to find the correct values for u and θ. Several students gave over-specified answers for both values. Some got as far as the simultaneous equations but could not solve them, and some made it more complicated than necessary by not substituting in the known values.

The alternative approach using conservation of energy was used successfully by several students.
While the majority of students found a correct approach, there were some very poor attempts from weaker students, suggesting little or no grasp of the theory or methods.

(b) A sizeable minority of students did not read the question carefully and found the time to move from *O* to *B* rather than the time from *A* to *B*. Most students used *suvat* equations correctly to find the time, although a sizable number made the task more difficult by finding the time taken to reach the maximum height, subtracting the given time to *A* from this and then doubling. This longer approach also tended to introduce rounding errors in the final answer.

(c) Surprisingly few students realised that the time of flight could be found from information already obtained previously, with many starting afresh and using vertical displacement to find the flight time. The method for finding the horizontal distance was well known but again over-specification was a common error.

Question 8

This question was very well answered by many students. Most successful students provided clear sketches showing their notation and the directions of motion of the particles at each stage.

(a) The use of conservation of momentum and the impact law was well understood. Most students formed two correct equations and went on to find a correct expression for the velocity of *Q* after the first impact. Many students understood that for *Q* and *R* to collide, the speed of *Q* after the initial collision must be greater than the speed *R* and were able to complete the question successfully. A significant minority did not think clearly about the requirements for a collision, and tried to work with $v_Q > 0$.

Several students worked with equations and then switched to inequalities with no justification. This approach gained no credit.

(b) Given a value for *e*, several students repeated all the working from part (a) to find the speeds of *P* and *Q* after the first collision.
Most solutions had the correct approach – forming equations using conservation of momentum and the impact law, then solving the resulting equations for the final velocity of *Q*. Confusing diagrams or the absence of a diagram often led to a sign error in the impact equation. An initial substitution of $e = \frac{3}{4}$ simplified progress as those who left the substitution until later often got bogged down and were more prone to making algebraic slips. Many, having correctly found the final velocity of *Q*, were unable to produce a valid conclusion because they had not found the final velocity of *P*. Another common error was to lose *u*, in the midst of the algebra, resulting in dimensionally incorrect statements.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:
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