Examiners' Report/
Principal Examiner Feedback

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Pearson Edexcel GCE in
Mechanics M2 (6678)
Paper 01

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This paper provided many opportunities for the well-prepared student to demonstrate their knowledge and understanding of the material studied. Parts of all questions were accessible to all students, and much of the work seen was completed to a high standard. Very few blank responses were seen.

The best work was legible, set out in a logical order and accompanied by clearly labeled diagrams. Well-ordered work is not only more straightforward to mark accurately, it is also easier for the student when they come back to check what they have done.

The rubric on this paper is very clear about the value that students should use if they need to substitute a value for g, and the accuracy that is expected after this substitution. However there are still students who lose accuracy marks by using the substitution $g = 9.81$ or by leaving their final answer with more significant figures than are justified.

Students should be advised to take care with calculations and to allow time for checking of their work. Throughout this paper there were many instances of students applying the correct principles but then losing marks through errors in the basic algebra and arithmetic

Question 1

(a) For many students this was a familiar and accessible topic with which to start the paper. Most students used the given information to find the value of *r* and write down the equation $4p + 2q + 11 = 3$. They went on to differentiate *v* to find *a*. A few students got no further than this because they did not realise that $a = 0$ when *v* takes its minimum value. Those students who did make this connection usually went on to complete the task successfully, although a few found the values of *p*, *q* and *r* but forgot to find the acceleration when $t = 3$. A few students used the method of completing the square to find the constants.
(b) Most students completed the integration correctly. Many also went on to use the correct limits and find the distance. However, many students were uncertain about the limits to use for "the third second" - they used $0 \le t \le 3$ or $3 \le t \le 4$. A small number of students completely misunderstood the request and used $0 \le t \le \frac{1}{3}$.

Question 2

The quality of the responses to this question was generally very good and showed that many students had a good understanding of Power, Energy and Work.
(a) The majority of students wrote down correct equations for the motion of the car up and down the road. Most errors were due to sign confusion in the equation for the motion down the road - two separate diagrams were often the key to success here. Some students used the powers 3*P* and *P* as their driving forces, but most students were able to use $P = Fv$ correctly in their equations and go on to solve for *P* and *R*. A number of algebraic errors occurred in solving the simultaneous equations. Some

students lost the final accuracy mark because they never expressed their final answers as exact multiples of g or to 2 or 3 significant figures.
(b) Most students tackled this part of the question successfully. The most common error in the work-energy equation was to account for work done against gravity in addition to the change in GPE, meaning that the equation contained an extra term. A few students omitted the work done against R or created a dimensionally incorrect expression by omitting the distance in their term for work done against R. The final accuracy mark was lost by some students for not rounding their final answer to 2 or 3 significant figures. A small number of students scored no marks, despite finding the correct distance, because they did not follow the instruction to "use the work-energy principle".

Question 3

It was very common for students to start their response to this question by equating a scalar to a vector. Despite this serious error, most students did find the change in momentum and then found its magnitude in terms of c. When finding the impulse a small number of students ignored the vector nature of momentum and used the change in speed rather than the change in velocity.
There were several basic computational errors: in simplifying the impulse vector a sign error was not uncommon and when applying Pythagoras' theorem, errors were made in squaring the terms or forgetting to square root or not squaring the given impulse of $2\sqrt{10}$.

Question 4

(a) Students who adopted a standard structured approach to this question with masses and clear calculations of distances of centres of mass from named lines were generally more successful than students who went direct to forming an attempted moments equation. There were a surprising number of errors in finding the areas of the triangle and quarter circle. The formula was given for the position of the centre of mass of the sector, but some students preferred to work from the formula given in the formula booklet. Some students found the geometry of the triangle challenging and there were many errors in finding the position of its centre of mass. Most students worked from an axis through O and adjusted their answer to find the required distance. Those students who used AD as their axis were more likely to make sign errors in their moments equation.
(b) Most students used their answer from part (a) correctly to find a relevant angle. Some students stopped at this point, but the majority went on to use a correct method to find the required angle. A clearly labelled diagram was very helpful here.
Some students did not notice that the question asked for the answer to be given to the nearest degree.

Question 5

(a) Most students spotted the most direct route through this question by taking moments about *A* and then resolving horizontally and vertically: this gave three equations which could be readily manipulated to form the required expressions.
Some students made it harder for themselves by taking moments about *B*, either instead of using *A* or as well as using *A*. In taking moments about *B* the most common error was to omit the friction acting at *A*, but there was also some trig. confusion and some sign errors occurred. The number of equations required can be reduced by taking moments about the points where the lines of action of *P* and the weight of the rod intersect and where the lines of action of *P* and the vertical component of the force acting at *A* intersect, but this approach was not seen.

(b) The great majority of students were able to interpret $\tan\theta = \frac{5}{12}$ correctly and they used this to substitute for $\sin\theta$ and $\cos\theta$ in their forces. Similarly, most students applied $F = \mu R$ correctly.

Question 6

(a) The majority of students made a strong start to this question, with correct equations for the horizontal and vertical displacement of the particle. Some went on to use $y = x$ rather than $y = -x$, and many gave their final answer as $\lambda = \frac{30}{7}$, which was inappropriate here due to the use of a decimal approximation for g. A few students could not see how to use the position vector of *A* and struggled to get an equation in one variable.
A significant minority made very little progress with the question because they confused the equations for horizontal and vertical motion. They stated the velocity as $(3\mathbf{i} + 4\mathbf{j})$ m s^{-1}, so they had not misread this information, and the question tells them very clearly that **i** is a horizontal vector and **j** is vertical.
(b) The majority of students understood that finding the speed and direction of motion required them to consider the velocity of *P*, not the displacement. Students who used $v = u + at$ to find the vertical component of the velocity usually fared better than those who used $v^2 = u^2 + 2as$ because correct working gave them the value -10 and they were then less likely to make errors in finding the direction of motion. Those using $v^2 = u^2 + 2as$ often gave an answer of $+10$ with no diagram to confirm correct direction.
Students with no diagram needed to be very clear in describing the direction of motion, for
example by stating that *P* is moving at an angle below the horizontal.
Only a small number of students used an energy approach to find the speed, but those who did were usually successful.

Question 7

(a) This was a standard question of its type and setting up the momentum and impact equations was very well done with velocities consistent between the two equations and very few sign errors. Most students found the correct solution to the simultaneous equations with just a few making manipulation errors. The most common error was to give a negative value for the speed of *A*, having found a negative value for the velocity.
(b) Many students recognised that they needed to consider the effect of the impact with the wall and to form an impulse-momentum equation with $3m$. The most common error was confusion in the impulse-momentum equation between the directions of the impulse and the approach velocity of *B*. As a result of this or other errors many students found a value of e greater than 1 but did not appear to spot that this must be incorrect. Those students whose work led to the velocity after impact with the wall being greater than the velocity before, or the particle continuing to move towards the wall after impact should have recognised that they must have made an error and checked back through their work. The working in this part of the question was often difficult to follow because u disappeared and reappeared from one line to the next - this is something that a student should be able to spot when they check through their work.
(c) A good comparison of the speeds of *A* and *B* was usually made, although it is sensible to quote the two speeds at this stage and not expect the reader to turn back to find the result of part (a). The best students were more explicit about the direction in which the particles were travelling, and compared velocities, not just speeds.

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