Examiners' Report/
Principal Examiner Feedback

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GCE Mechanics M2 (6678) Paper 01

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Introduction

The majority of candidates were able to make progress with all of the questions in this paper, although some parts of some questions did prove to be quite challenging. Very few responses to question 7 showed any signs of candidates being short of time.

There was a wide variety in the way the candidates presented their answers. There were some elegant, concise solutions but others that rambled on and some that were quite difficult to read. Some candidates are very good about defining variables that they use and explaining their working, but there is some work where it is very difficult to follow what the candidate is doing. Where a question has a given answer, candidates need to remember that they need to show sufficient working to demonstrate that they have reached the required result.

The rubric for this paper specifies that candidates should be using $g = 9.8 \text{ m s}^{-2}$. Candidates who use 9.81 will lose accuracy marks. Similarly, candidates need to understand that they can not achieve an exact answer after the use of an approximate value for g.

Question 1

Most candidates gave confident responses to this question, which is of a similar style to many that they will have seen before. There are still a few candidates who do not understand that it is not appropriate to use the *suvat* equations in a question involving variable acceleration.

In part (a) the differentiation was usually correct. There were a few arithmetic errors in substituting $t = 1$, and some candidates left their answer for the acceleration as a vector rather than going on to find the magnitude.

In part (b) the integration was often correct. Some candidates did not have a constant of integration (or use a definite integral), and some were confused about the value of t to use - use of $t = 1$ was a common error. Of those candidates who completed the integration correctly, there were several who made arithmetic slips in substituting $t = 3$.

Question 2

(a) Many candidates gave correct equations for conservation of momentum and the impact law. If there were errors these were usually sign errors in the impact law, with many having the speed of approach as u rather than $3u$. It was more common to find errors when candidates were using a formulaic approach rather than thinking of "speed of approach" and "speed of separation". Some candidates struggled to use their simultaneous equations to find an expression for the speed of Q, often going a very long way round to get to their answer.

(b) Having found an expression for the velocity of P, many candidates did not realise that the question simply required them to use sign as an indicator of direction. Some thought that they needed to consider the relative velocities of P and Q, and several went back to the beginning of the question and repeated all their working having changed their initial assumption about the direction of motion of *P* after the impact. Some candidates with correct solutions lost the final mark because they did not consider the upper limit to the range of possible values for *e*.

Question 3

(a) Many students found the value of *F* correctly, usually by following the most direct method of taking moments about *A*. There were a few errors with sin/cos confusion and some candidates omitted one or more lengths from their moment's equation.

(b) Having used moments in part (a), many candidates tried the same approach here. The majority tried to take moments about *B*, but they usually omitted the horizontal component of the force acting on the rod at *A*. The other common approach was to resolve vertically, but this also proved difficult because many candidates considered the component of *F* perpendicular to the rod rather than the vertical component of *F*. Some candidates did give completely correct answers to this part, but many were confused by the simplicity of what they were being asked and preferred to give the magnitude and direction of the force acting at *A*, rather than work on just the vertical component of that force.

Question 4

(a) This part of the question was largely answered very well. Most solutions were accompanied by a clear table of masses and distances. Whilst most candidates took moments about *P* to give the required answer directly, several chose to take moments about the centre, or about the left-most point. Some candidates simply went directly to the answer, but, as this was given in the question, a clear explanation of their method was required. This question involved complete circles, and the position of the centre of mass of each circle could simply be written down, but it was common to see weaker candidates trying to use the formula for the position of the centre of mass of a sector of a circle.

(b) The candidates really needed to understand what was going on to score full marks in this question. There were several possible approaches, some of which were very concise. Many candidates did not realise that by adding a mass at *P* and suspending the lamina from *S* the diameter *ST* , as shown in the question, would rotate clockwise about *S* and the centre of mass of the system would lie on *OP*. Another common error was to assume that the centre of mass would be at *O*, and simply ignore the information given about the angle. One of the simpler approaches was to take moments about *P*, but the candidate then needed to realise that their moments equation involved a distance measured from *P* and when they used $\tan\alpha = \frac{5}{6}$ they found a distance measured from *O*.

Question 5

Despite being on a familiar topic, this question was not answered well, possibly because the candidates are used to seeing it presented in vector form. It was common to see candidates trying to use the impulse of 12.5 in an impulse-momentum equation without understanding that it is a vector equation. Many candidates offered the incorrect equation $12.5 = 0.25(v - 30)$ leading to $v = 80$.

The most successful approach was either to adopt vector notation or to deal with the horizontal and vertical components separately. There was some trig confusion in finding the components of the impulse, and there were sign errors in the component parallel to the initial direction. The question does ask for the speed of *B* after the collision, so answers left as vectors did not earn this mark.

Very few candidates adopted the vector triangle approach.

Question 6

(a) Students who considered the system as a whole were often more successful than those who considered the car and trailer separately. The most common error was to omit one or more of the forces acting, often the weight of one of the objects, or one or both of the resistances.

(b) Although many correct answers were seen, some candidates struggled to write down a correct equation for the motion of the car or the trailer alone. It was common to see the acceleration ignored, or the weight or resistance missing from the equation.

(c) This part of the question was answered well. The majority of candidates now accept that if the question specifies that they must use the work-energy principle then they will earn no marks for an alternative approach. The most common error is still to see candidates double counting the change in potential energy by considering both the gain in GPE and the work done against the weight. Some candidates forgot to include the work done against the resistance. There did seem to be some confusion about what happens when the towbar breaks. Although the question clearly asks for the additional distance travelled by the trailer, some candidates considered both vehicles as if they were still attached, and some considered only the car.

Question 7

(a) Although this was a straightforward question, the fact that the answer was given in the question places the onus on the candidate to show all working clearly. This needs to include a clear indication of the method used, with values substituted in the formulae, together with the value of u^2 if the candidate has used the most direct route via $v^2 = u^2 + 2as$.

(b) The majority of candidates used s = -52.5 and found the time by solving the resultant quadratic equation. Those who chose to break up the motion into separate parts cost themselves time but were usually successful, provided that they used exact values for the times for each element. The most common mistakes were sign errors and slips in using the quadratic formula to solve for t. Those who found the time correctly were generally successful in producing an entirely correct solution although some candidates did forget to combine the horizontal and vertical components of the speed of projection. There were a number of variations seen with quadratic equations in $\frac{50}{u_h}$ or in u and α, the original direction of motion.
Inappropriate accuracy of the final answer was not common, but candidates should remember that it is not correct to leave the overall speed of projection as a surd or to use more than three significant figures after the use of an approximate value for g.

(c) This proved to be the most challenging part of the question, with many candidates not identifying the required direction correctly. Many attempts used displacement rather than velocity. Those who managed to identify the correct direction and find the vertical component of the velocity often made a sign error when they used $v = u + at$ to find t.

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