Examiners' Report/
Principal Examiner Feedback

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GCE Mechanics M2 (6678) Paper 1

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Introduction

This paper proved to be accessible to the majority of candidates and many correct and clearly presented solutions were seen.

The standard of presentation was good, but all candidates need to be reminded of the need to make their final answer clear, and to ensure that they have addressed the demands of the question. If a candidate changes their mind about an answer, they should be aware that attempts to overwrite the original frequently result in work that is barely legible. Similarly, very small writing using a felt tip type pen can produce an illegible scrawl.

Many candidates are confident when working with vectors, but some are clearly not aware of the difference between vectors and scalars. Some candidates will go to great lengths, often making the task more difficult, in their attempt to avoid working in vectors.

Many candidates are losing marks as a result of giving their final answers to an inappropriate level of accuracy. In calculations the numerical value of g which should be used is 9.8, as advised on the front of the question paper. Final answers should then be given to 2 (or 3) significant figures – overspecified answers will be penalised, including fractions. Premature rounding at intermediate steps also results in incorrect final answers.

In all cases, as stated on the front of the question paper, candidates should show sufficient working to make their methods clear to the Examiner. If the question asks candidates to obtain a given answer then they need to ensure that they show sufficient detail in their working to warrant being awarded all of the marks available.

If a candidate runs out of space in which to give his/her answer than he/she is advised to use a supplementary sheet – if a centre is reluctant to supply extra paper then it is crucial for the candidate to say whereabouts in the script the extra working is going to be done.

Report on individual questions

Question 1

This question provided a very straight forward start to the paper, with many candidates scoring full marks. The majority of errors were due to slips in the arithmetic. Most candidates did consider a change in momentum, although the terms were sometimes subtracted in the wrong order. Candidates who added the initial and final momentum scored zero. The vectors caused confusion for some candidates who combined **i** and **j** terms inappropriately.

Too many candidates went on the find the magnitude of **v** which, although not penalised on this occasion, suggests that they were not reading the question properly, or did not know the difference between speed and velocity.

Question 2

a) The majority of candidates were able to substitute $t = 4$ into the expression for **v** to find the velocity at $t = 4$. It seems that some candidates still fail to appreciate the difference between speed and velocity as several did not go on to find the speed.

b) Very few candidates were unable to obtain **a** from **v** correctly. A significant number of candidates chose to go on to find the magnitude of the acceleration. This was not penalised on this occasion, but raises the question of whether they know that acceleration is a vector.

c) This was often well answered, but the candidates did find it more difficult than parts a) and b). When the integration was completed correctly the constant was not always included, or was assumed to be $-4\mathbf{i} + \mathbf{j}$ without any working shown. When the constant was included, the substitution of $t = 1$ was a source of some careless errors. A common error was to see **i** and **j** combined so that $t^2\mathbf{i} - t^3\mathbf{j}$ became $1 - 1 = 0$. When the expression for the position vector was simplified there was often sign confusion (usually with the $- t^3\mathbf{j}$ term). There were also a significant number of careless arithmetic errors, with $16 - 5 = 9$ seen several times.

Despite having found an expression for **a** in terms of t in part (b), a small number of candidates failed to appreciate that integration was required for this solution and attempted to apply equations for constant acceleration.

Question 3

a) The majority of the candidates found the correct equation of motion and almost all went on to use '$P = Fv$' correctly. Too many candidates gave a final answer of 828.7 watts, which is an inappropriate level of accuracy following the use of $g = 9.8$. Some candidates mistakenly assumed that there was an acceleration of 0.2 m s^{-2}, and some ignored the deceleration completely and used $a = 0$.

b) This question clearly states that candidates are required to use the work-energy principle. Candidates who approached the question by using $F = ma$ scored no marks. It was disappointing to find several candidates using this alternative method. Some candidates chose to use both methods, answering the question twice, as a means of checking their work-energy solution, this is of course perfectly acceptable.

The most common errors were to miss out a term in the work-energy equation or to include an extra GPE term. Some missed out either the work done against resistance or the GPE term, but a substantial number of candidates considered both the increase in GPE and the work done against the weight, apparently not realising that these terms are the same thing. Candidates need to be warned that incomplete work-energy equations and equations with duplicated terms are given no marks. Less common, but equally serious in terms of marks, was the inclusion of 20 rather than $20d$ as the work done against resistance - an inconsistent equation mixing energy and forces is considered a method error.

With the correct number of terms in the energy equation, there were still sign errors made. There were also errors in the weight term, such as using mass instead of weight and confusion of sine and cosine.

Question 4

a) Most candidates chose to split the shape into a composite body consisting of a rectangle and two triangles. The usual alternatives were a larger rectangle with two triangles removed, or a large triangle with a smaller one removed. The use of three equilateral triangles was also seen, but only rarely. The given answer was a help to candidates who were having difficulty dealing with the height of the trapezium and the positions of the centres of mass, prompting a review their work if necessary.

Initial results concerning the masses and positions of the centres of mass were often tabulated, thus making the work clearer, and easier for the examiner to check. Most candidates were able to take moments about a horizontal axis in order to find the required distance. Many took moments about *DC* rather than *AD*, but were able to go on to obtain the given result. The given answer did result in a few candidates producing contrived work to gain the correct answer. Almost without exception, all calculations were dealt with in surd form.

b) There were many correct solutions, however many candidates chose to take moments about a vertical axis (often done in part (a)) to find the horizontal position of the centre of mass, completely failing to recognise the symmetry of the shape. Most were able to identify the correct triangle to use to find the required angle (often confirmed by referring back to the original diagram). Common errors included using a horizontal distance of 2 rather than 1 and slips in using the vertical distance given in part (a).

Question 5

This was a similar question to those set on this topic in the recent past and was well answered by the majority of candidates. More students than usual were finding the quickest way to get the answers. The friction was acting in the right direction and nearly all normal reactions were normal.

a) Most candidates started by taking moments about A. The most common error was to resolve the tension but then only consider either the horizontal or the vertical component. Some candidates gave a final answer with more than three significant figures, which was inappropriate following the substitution of a value for g.

b) Most candidates chose to resolve in two directions and were able to combine their values to gain a figure for the coefficient of friction. Those who resolved vertically and horizontally had a simpler task and were nearly always successful. Resolving parallel to and/or perpendicular to the rod was less successful - frequently resulting in equations that omitted the friction at A. Similarly, those candidates who chose to take moments about B often failed to reach the correct answer because they had left out the weight or the friction at A.

Question 6

a) Candidates were confident in producing equations for conservation of momentum and the impact law. Some candidates were inconsistent in the uses of signs in the two equations, and on occasions produced some dubious algebra which resulted in either fortuitously ‘correct’ results or the speeds in ‘reverse’ order. Candidates should be encouraged to look at their results in the context of the question – it is impossible for particle A to be travelling in the same direction as B, but more quickly, after the impact detailed in the question. This question asked for the speeds of the two particles after the collision, and some candidates are still not making the distinction between speed and velocity.

b) Provided the answers to part (a) had been obtained correctly, most candidates were able to achieve the given answer. Most tackled (final KE – initial KE) successfully for the whole system. The few sign errors that were made came in solutions in which energy loss was treated separately for each ball. A few made algebra errors but most got to the given answer with ease and even managed to justify losing a minus sign at the end where necessary.

c) Very few candidates took the obvious short cut (answer from part (a) multiplied by 5/6). Everyone else laboured through the simultaneous equations. A handful got lost or confused but the vast majority worked through successfully as they had in (a).

Question 7

a) A great variety of approaches was in evidence. Most candidates were comfortable with the vector format of the question and set about considering horizontal and vertical components of the motion. The simplest approach of working with the time rather than going via calculation of the distance AB or OB was more often successful. A small minority confused the **i** and **j** components of velocity, effectively taking **i** as vertical and **j** as horizontal, and some misinterpreted the relationship $OB = 2AB$. A common error was to over specify the final answer, or to imply an exact answer of $\frac{90}{49}$.

It was disappointing to see several candidates trying to force the problem back into a non-vector form by calculating the angle of projection and then resolving. A few of these candidates were successful, despite using an unnecessarily complicated method.

b) Nearly all attempted to find the vertical component of velocity using *suvat.* Some stopped at this stage, but most went on to state the horizontal component of velocity and to find the speed. Occasionally an error was generated by using their rounded answer of 1.8 from part (a) in calculations in (b). Candidates should avoid the temptation to use approximate values in their working too early. The use of $t = \frac{18}{g}$ here would have led to simpler equations and more accurate answers.
A few candidates tried to solve the problem in a multipart style, by considering motion to the maximum height and then motion from the maximum height, but were rarely successful and their multipart answers were not clearly labelled neither was their approach explained.

The energy method was occasionally employed, usually successfully.

c) It is pleasing to note that many candidates were able to use the symmetry of the path to deduce that the vertical component of the velocity at *C* is +6; this then gave a quick solution to the problem.

Some candidates confused their answer to part (b) with the vertical component in (c).

Longer alternative methods, usually involving vertical distance, were also seen, but all too often accuracy errors arising from premature approximation led to a loss of marks.

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