Examiners' Report
Principal Examiner Feedback

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In Mechanics (WME02) Paper 01

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Introduction

The majority of candidates found this paper accessible with most offering solutions to all of the questions and time did not appear to be a limiting factor.

If there is a given or printed answer to show, as in questions 4(a), 5(a), 6(a) and 7(b), then candidates need to ensure that they show sufficient detail in their working to warrant being awarded all of the marks available and in the case of a printed answer, that they end up with **exactly** what is printed on the question paper.

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 and correct answers without working may not score all, or indeed any, of the marks available.

In calculations the numerical value of g which should be used is 9.8 m s^{-2}. Final answers should then be given to 2 (or 3) significant figures – more accurate answers will be penalised, including fractions. There were some candidates this time who lost accuracy marks in questions 3 and 5 due to the use of $9.81\,\text{m}\,\text{s}^{-2}$ and/or giving an answer to 4sf.

If a candidate runs out of space in which to give their answer then they are 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 can be found.

Candidates who have spare time at the end of the paper should check through their work very carefully. Many marks were lost unnecessarily – through rounding errors, not reading the question properly, not reading specific instructions in the question, basic arithmetical mistakes, sign errors following correct equations, omitting **i** and/or **j** in vector equations and candidates misreading their own writing.

Question 1

Variable acceleration in 2-dimensions provided an accessible start to the paper with many fully correct solutions.

(a) The vast majority of candidates were able to integrate both components of velocity correctly to find an expression for displacement. Whilst most remembered to include the constant of integration, some candidates assumed it to be $-30\mathbf{i}-45\mathbf{j}$. Those who expanded $(t+2)^2$ before integrating were more successful in both stages of the process. Although less popular, definite integration was almost always carried out correctly.

(b) Candidates recognised the need to differentiate velocity to find an expression for acceleration before substituting the value of $t = 3$. On the whole, accurate differentiation gave both components of acceleration successfully. Unfortunately some candidates did not recognise the need to use Pythagoras to find the magnitude of acceleration to earn all available marks in this part.

(c) Candidates confidently used the given direction together with the ratio of **i** and **j** components to find the correct value of t and reject the value that was not required.

Question 2

In general candidates were able to navigate this question using impulse as a vector, to arrive at the correct velocity, 6 **i**+9 **j**. However for many it proved to be very challenging.

All marks are awarded whenever a correct solution is produced but some answers of 6**i**+9**j** came from solutions with multiple errors and these could not receive full marks. Candidates must take care to use mathematical notation correctly, particularly in questions that combine vectors and magnitudes. Unfortunately many responses included incorrect notation such as $\mathbf{j}^2$ and candidates were not clear when to use velocity and when to use speed. For example, substituting and expanding $(x\mathbf{i}+y\mathbf{j})^2$ for v^2 in the KE equation.

It is recommended that candidates read questions carefully and then check that they have understood the information sufficiently well before embarking on their solution. In this question a particle moves on a horizontal surface but some candidates took **i** to be a horizontal unit vector and **j** to be a vertical unit vector which would imply projectile motion. Information was given about *KE* **gained** in the collision but some candidates used the value as the **final** *KE*.

Many well-prepared candidates, earned the first 3 marks in a single equation, applying Pythagoras to the change in momentum and equating it to the given magnitude. They earned the next 2 marks from a correct energy equation and the final 2 marks by eliminating $x^2 + y^2$ and completing the question to find the velocity.

Question 3

Although this was a popular question on power, work and energy, several candidates did not take note of the instructions on the front of the paper: some used 9.81ms^{-2} for *g* and some gave answers as fractions or with 4sf. Both errors are penalised so candidates should be advised check to their final answer whenever *g* is used in a question.

(a) Candidates who were well-rehearsed in forming an equation of motion for the whole-system appeared to do so with ease. They combined this with $P = F\,v$ to gain 5 marks in just a couple of lines of neat working. For a minority, the only mark earned in this part was for the power equation. When forming the equation of motion, the forces must correspond with the mass in the *ma* term to earn marks. There must not be additional forces or missing forces and any weight terms must be resolved. Weaker candidates are more likely to process forces somewhere on their page and then divide by a mass to get an acceleration. The marks for an equation of motion are awarded when the resultant force, appropriate mass and acceleration, come together in an equation, so this approach can delay the awarding of marks and is more likely to see errors creep in.

(b) Those who were well-rehearsed considered the trailer only and successfully combined the *KE*, *GPE* and work-done to earn 4 marks in just a couple of lines. In a work-energy equation, all terms must be included and there cannot be extra terms. Some candidates double-count *mgh* by listing it as *GPE* and also in their work-done term which causes a significant loss of marks. Other candidates used the mass of the van or the combined mass which is not appropriate here. It is common for all candidates to list the required terms on their page before combining to form an equation. In a few cases, candidates miscopied their terms, or did not read their own writing correctly, which led to a loss of marks.

Question 4

For questions on centre of mass, it is increasingly common for candidates to present their masses (or mass ratios) and distances using column vector form rather than the more traditional table. In both cases, those with clear presentation are usually successful. However, candidates must remember to extract the required expression from their vector equation at the end of their working.

(a) This part was the first 'show that' question on the paper and candidates were usually very good at reaching the required distance for the centre of mass. To fulfil the 'show that' requirements, a candidate should clearly present a moments equations with each term written as a product of the relevant mass (or mass ratio) and distance. The required distance was defined in the question as d and several lost the final mark because they did not find d, reaching a value for $\bar{y}$ instead. Those using column vectors often found both distances at the same time, possibly assuming that the other will be useful later in the question which, on this occasion, it was not. Candidates should be advised to *show* a line of working between their initial equation and a given answer in an exam, even if it is very simple rearranging or cancelling.

(b) A large proportion of candidates did not use symmetry to simply state the distance of the centre of mass from *PQ*. Instead, a lengthier process introduced errors into calculations which resulted in an incorrect final answer. Although candidates used the given answer from part (a), many did not make the adjustment and add a to give the distance from *PS* instead. Despite this, many took their two distances and used tan to complete the question.

Question 5

Although projectile motion is often well-answered, performance in this question had the usual loss of marks for candidates who did not take note of the instructions on the front of the paper: some used 9.81ms^{-2} for g and some gave answers as fractions or with 4sf. Both errors are penalised so candidates should be advised to check their final answer whenever g is used in a question.

(a) Many candidates did not understand how to fulfil the 'show that' requirements, earning only two out of six possible marks. Candidates are expected to know how to apply constant acceleration formulae to derive equations for projectile motion. In an exam, the 'show that' phrase should prompt candidates to show, from first principles, how the constant acceleration formulae lead to the given answer. Those who state a time of flight formula for example, without showing where it comes from, cannot earn all available marks.

(b) Most candidates understood the connection with the given answer in part (a) and used it correctly to find the distance *AB*. Unfortunately a number did not show a complete method by subtracting 12 from their *AB* to find the required distance, and therefore lost both marks.

(c) The vast majority earned the first two marks by using horizontal motion to find the required time. Following this, the next mark was also earned by most as the time was used, with vertical motion, to find a relevant vertical height. To find the required height, candidates needed to subtract 5 from their answer. Unlike part (b), this final adjustment was rarely forgotten.

Question 6

Many candidates find static rigid bodies a challenge and could perhaps perform at a higher standard by taking time to carefully label a force diagram. In this question, weaker candidates would often have a partially-labelled, or squashed, force diagram followed by chaotic working with very little opportunity to award marks.

(a) Although the vast majority knew that the value of k could be found efficiently by taking moments about A, many did not understand the 'show that' requirements of this part and lost most or all of the available marks. The most successful candidates took moments about A, with each term clearly written as the product of a perpendicular force and distance, using W and a appropriately. This approach established a dimensionally correct moments equation to *show* how the value of k is found. Candidates should be advised to *show* a line of working between their initial equation and a given answer in an exam, even if it is very simple rearranging or cancelling.

(b) The most efficient and most popular approach was to form a vertical equilibrium equation, a horizontal equilibrium equation and combine using $F = \mu R$. This was carried out successfully by most candidates. However, a significant number had very poor presentation, making it difficult for examiners to know where to award marks. From this group, many ignored W and wrote down equations that were dimensionally inconsistent eg $F = \frac{56}{13}\sin\theta$ where newtons are on the LHS but the RHS is a constant. Others wrote expressions, rather than equations, around their page before producing an answer, leaving examiners to deduce their method. Candidates should be advised to state and form equations clearly to help make their method clear.

Question 7

This question on successive collisions brought with it the level of challenge expected for the last question on the paper. It was pleasing to see many solutions earning most of the marks available with the final part discriminating between the grades.

(a) The majority of candidates earned the first 4 or 5 marks for routine bookwork with clear, organised presentation. Many continued successfully, recognising how to use the unchanged motion of P to form an inequality, and therefore an inequality for e. It was very pleasing to see that final answers were almost always presented with both ends of the inequality for e.

(b) Candidates were very successful in this final 'show that' part of the paper. It was most common to use the impulse to find an expression for y and then substitute this into the Impact Law to reach the given answer for e. Those who made sign errors along the way were often able to use the given answer to find their mistake and correct their working.

(c) Although many candidates attempted the final part of the paper and achieved the first mark, some abandoned the question at this point. The most popular approach was to establish the equations for *CLM*, Impact Law and then Impulse, achieving the method mark if all the necessary stages were included and equations were dimensionally correct. However, this lengthy process often introduced an error along the way leading to an incorrect final answer. It was rare for candidates to see the scale factor relationship between the initial scenario and the final scenario. Whilst the working did not appear to be spontaneous or routine, the most able were prompted by the small number of marks to pause and consider the problem. Those who recognised the $\frac{1}{7}$ scale factor, were then able write down the correct answer with minimal working.

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