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GCE

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Introduction

This paper proved to be accessible to most candidates, who commonly offered responses to all eight questions. Much of the work was of a high standard, with many clearly presented and concise solutions, particularly in questions 1, 2, 3 and 8. Some candidates were not so confident with the motion of a projectile described in vector form, and the lack of direction towards an appropriate method in question 7 made this more challenging. Candidates do need to be reminded to read the questions carefully, and to ensure that they have answered appropriately - many found the change in kinetic energy in question 2, rather than the kinetic energy after the impulse. Similarly, many candidates lost a mark because they did not give the final answer in question 5 to the nearest degree. Although it has been commented on in previous reports, candidates are still losing marks through giving final answers to an inappropriate level of accuracy following the use of 9.8 ms^{-2} as an approximate value for g. The general level of arithmetic and algebraic skills was good, with fewer candidates sacrificing marks through careless errors. The given answers in some questions allowed candidates to identify and correct errors. As usual, the best work was accompanied by clearly labelled diagrams - all candidates should be encouraged to use diagrams to present and summarise information whenever possible.

Report on individual questions

Question 1

This proved to be a friendly starter for most candidates. Part (a) most candidates obtained the correct answer, although there was often no clear statement that the driving force must be equal to the resistance. In part (b) there were many completely correct solutions. The most common error was to omit the resistance when writing down the equation of motion, often when a candidate had not drawn a diagram of forces.

Question 2

This was well answered by the majority of candidates, many of whom gained full marks. Most equated impulse to change in momentum, but the subtraction was sometimes done the wrong way round. A few candidates made errors due to the poor use of brackets. Most candidates went on to find the kinetic energy correctly. Calculation of the magnitude of the velocity was often correct, but there were arithmetical errors and slips such as squaring a component twice. Some candidates did not appear to understand that kinetic energy is a scalar and gave their answer in terms of **i** and **j**. $\sqrt{29}$ and 3 were common incorrect answers.

Question 3

The vast majority of candidates knew that integration was required for parts (a) and (b) and they performed this competently with only a small minority omitting the constants of integration. A small number did try to use *suvat* inappropriately, and one or two differentiated instead of integrating. Part (c) most candidates knew that they needed to put $v = 0$ and most of these recognised the equation as a quadratic in t^2 and factorised or sometimes completed the square to obtain values of 2 and 4 for t^2. The final mark was occasionally lost by a failure to reject negative values of t. Candidates who did not recognise the quartic as a quadratic in t^2 sometimes went to considerable lengths to use the factor theorem and/or trial and improvement to find factors of the quartic, but they rarely reached the correct final answer. Another common error was to rearrange the equation as $t^4 - 6t^2 = -8$ and attempt to set factors of the left hand side equal to factors of -8.

Question 4

In part (a), some candidates interpreted the question as requiring just the work done against friction. Another frequent mistake was finding the correct frictional and gravitational forces but then failing to multiply by the distance. Some candidates double counted by including both the increase in gravitational potential energy and the work done against the weight of the box. The final answer was often given as 8481J, which is inappropriate following the use of an approximate value for g.

In part (b) the solution was often correct. Some candidates using the work-energy principle did make errors through double counting, and sometimes made a sign error by attempting to use their answer from (a). The alternative method of using $F = ma$ and *suvat* was usually successful provided the candidate did not omit the friction.

Question 5

In part (a) there were many entirely correct solutions to this question, with candidates employing a number of different strategies to split this shape into standard components. Most commonly this involved expressing it as the difference between two triangles, or splitting it into two rectangles and two triangles. Using just two triangles tended to produce the most concise and accurate solutions, although there was some confusion over the positions of the centres of mass of the triangles. Some candidates did not realise that they could work in terms of the horizontal and vertical distances from these vertices at *B* and *E* and went to considerable lengths to calculate the heights of the triangles measured from these vertices and then to use trigonometry. Candidates who divided the shape into four or more pieces frequently made errors in calculating the areas of these pieces or in locating their centres of mass. Another cause of errors was to double count a region, or even to leave it out entirely. A small number of candidates treated this as a structure made of rods rather than as a uniform lamina. A surprising number of candidates did not use the symmetry of the lamina to find the second distance, with many reworking a moments' equation to get the same answer – or in some cases a different answer. Part (b) was very well answered by most candidates; the required angle was usually identified correctly and candidates could gain two marks for work clearly following from incorrect values in(a). A common incorrect answer was 45º, from candidates who did not consider the geometry of the situation or use a diagram to help. Many candidates did not round their final answer to the nearest degree.

Question 6

Solutions in part (a) often lacked a clear method. Candidates should be reminded of the need for detail when deriving a given answer. Candidates showed a poor knowledge of vector analysis and little understanding of the use of a displacement vector with a position vector. There were plenty of fudges to include 10j, only rarely was $\mathbf{r} = \mathbf{r}_0 + \mathbf{s}$ used. Many candidates considered the horizontal and vertical components separately. The horizontal component was easily found but the candidates found it difficult to justify the 10 in the vertical. Many, incorrectly, attempted to equate the vertical displacement to 10 without any reference to initial conditions. The best solutions used integration, with the 10 being found by using the initial conditions to find the constant of integration.

The best solutions in part(b) were where candidates equated the **j** component of their position vector to 0 and solved the resulting quadratic equation. Many started again and found the vertical displacement equation from scratch leaving a greater scope for error. A common error was to equate the **j** component from (a) to 10, failing to realise that the 10 was already included in the equation. As usual, there were a few unnecessarily long methods involving calculation of the time to reach the maximum height and then the time from there to the ground. Some candidates lost the final mark due to ‘over accurate’ answers following the use of a decimal approximation for g.

In part (c) some candidates clearly differentiated the result from part (a), and others derived the velocity from the initial information. There was evidence of confusion on some candidates who found the speed or velocity at a particular time, rather than a general expression for the velocity. Part(d) surprisingly, many candidates had difficulty here , commonly equating their *j* component to +3 rather than -3, often despite having a correct diagram. Others did not connect "45° below the horizontal" with equal horizontal and vertical components of velocity.

In part (e) many candidates had success here despite earlier problems, with most finding the modulus of a vector of the form 3**i** + n**j**. Candidates should be encouraged to read all parts of questions as later parts do not always rely on success in earlier ones.

Question 7

Although there were many fully correct responses to this question, the unstructured nature of the problem did present difficulties for some candidates. A clearly labelled diagram showing all the forces was essential. Some candidates were unsure of the direction of action of the normal reactions at *A* and at *C*. Some gave them both the same name, and appeared to believe that they were equal in magnitude. Others omitted at least one of the normal reactions. Some candidates used horizontal and vertical components for the force at *C* but were usually unable to connect them later in their solution. Many candidates recognised the need to take moments and to resolve but errors were often made in doing so. The most straightforward approach of taking moments about *A* and then resolving vertically and horizontally was often seen. Many candidates took moments about *C* or tried to resolve parallel to and perpendicular to the rod, but this frequently resulted in a missing term. There were a small number of more imaginative solutions involving moments about points not on the plank. Although there was evidence of confusion between sine and cosine when resolving forces, incorrect solutions usually involved an attempt to resolve when it was not necessary, or a failure to do so when it was required. Equally, it was common to find distances missing from a moments equation. Despite having correct equations many candidates could not combine them to find friction and reaction forces correctly. Some candidates did demonstrate that they were finding the least possible value of μ, but many did not address this point and used $F=\mu R$ throughout. A few candidates misread the question, using 100g as the weight.

Question 8

Candidates found this impact question more straight forward than some in recent years. In part (a) many candidates derived the given answer correctly. A few made sign errors in equating the change in KE to energy lost and a small number were not able to complete this part because they could not find the speed immediately after the impact. Part (b), a lack of clear diagrams sometimes led to sign errors and confusion over the direction of motion of the particles after the collision, but many candidates gained full marks in this question. Most candidates formed a correct equation for the conservation of momentum, and there were fewer errors this time in applying Newton's Experimental Law. There were arithmetic and algebraic errors in solving the simultaneous equations, but the standard of justification of the second collision was good.

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