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Examiners' Report/ Principal Examiner Feedback

Summer 2012

GCE Mechanics M4 (6680) Paper 01

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Summer 2012
Publications Code UA032683

Introduction

The standard of the work seen varied considerably, with many concise, accurate solutions to all of the questions and some poorly presented work which did not appear to follow any logical order. Some candidates are clearly being selective about which questions they attempt, with full answers to some questions and completely blank responses to others. Although relative velocity appears to be the topic that candidates find most difficult, blank responses were seen for all of the questions. All candidates need to be reminded of the importance of making their methods clear and defining any variables that they introduce. Clear, annotated diagrams are often the beginning of a well presented response. Illegible work is likely to gain no credit - the examiners had real difficulty with some scripts this year.

The rubric for this paper specifies that candidates should be using $g = 9.8 \text{ ms}^{-2}$. 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

(a) Most candidates knew what they needed to do in this question, with many correct equations seen for conservation of momentum and the impact law. Only a small number of candidates used the impact law the wrong way round. Those candidates who chose to work with separate components of the velocity of *S* after collision rather than a speed and an angle generally worked through the question more easily.   Some seemed to lose their way - often because they didn't define their own variables clearly enough.

(b) Many candidates made a good attempt to find the direction of motion of *S* relative to the line of centres immediately after the collision, but relatively few went on to find the required angle correctly. A small minority of candidates used the scalar product here, usually to very good effect.

Question 2

This question in particular exemplified the need for clarity of diagrams and definition of quantities involved. Some candidates struggled to make any progress, while others offered neat, elegant and concise solutions. Most solutions that gained any credit followed either a vector approach or a geometrical approach.

Using vectors, there was a lot of good work, but relatively few candidates were able to arrive at a correct expression for the position of the ships relative to each other at time t. There were often sign errors in finding the relative velocity, and some confusion about the distance *AB*, with the initial 3 km easterly displacement being forgotten when finding the distance apart later on. Candidates who found the full expression for the relative position before attempting to respond to the specific demands of the question tended to do better than those who developed it piece by piece through their response.

Some candidates made good use of geometric methods, particularly those who were able to distinguish clearly between the geometry of the velocity diagram and that of the spatial arrangement of the problem. When completed correctly, this approach produced some of the best solutions.

Question 3

A surprising number of candidates offered no attempt at part (a) of this question, and simply went directly to part (b) to solve the differential equation. These candidates then had nothing to refer back to when it came to part (c).

(a) Candidates were expected to write down an equation of motion for each particle, eliminate the tension and derive the given differential equation. Some candidates did not include the tension on their diagrams or in their equations at all. A large proportion of candidates considered the system as one entity, often ignoring the tension, and sidestepping the issue that they were trying to apply Newton's laws round the pulley. In reaching the given differential equation, there were many fudged attempts to introduce a factor of 2 without explaining how $\frac{\mathrm{d}v}{\mathrm{d}t}$ becomes $\frac{\mathrm{d}}{\mathrm{d}x}(v^2)$.

(b) Although the format given for the differential equation was possibly steering candidates towards the integrating factor approach, candidates found several valid ways to solve for v^2. The integrating factor method was the most straightforward route, but many candidates preferred to treat it as a variable separable equation working either with $\frac{\mathrm{d}}{\mathrm{d}x}(v^2)$ or with $v\frac{\mathrm{d}v}{\mathrm{d}x}$. This approach was often successful, but there were several errors in dealing with the constants.
The third popular approach was to work via an auxiliary equation. This should have been straight forward, but confusion between first and second order equations led to complementary functions involving $(A + Bx)$, and some candidates struggled to find a particular integral.

(c) Only a minority of candidates had any success with this part. The first two marks should have been available to anybody who could go back to their initial equations and use the fact that the particles are released from rest. The remaining marks did rely on having a correct expression for v^2.

Question 4

Many candidates found this relative velocity question quite approachable with both geometric and component methods being used successfully.

(a) Most solutions started with a vector triangle, but a large number had the current flowing in the wrong direction. Candidates with an incorrect triangle were still able to work through the question, but they had lost their accuracy. Most candidates started by finding a relevant angle, but some had difficulty using this to find the bearing.
Those candidates who equated the components of the resultant velocity used a variety of methods to tackle the resulting trig. equation to obtain an angle..

(b) The majority of candidates were able to use their angle from (a) with the sine rule to find the relative velocity, and hence the time taken to close the gap of 15 km.

(c) & (d) Success here was quite independent of the work that had gone before. Many good candidates did not realise that both vessels would be affected in the same way by drifting with the current. For some candidates these were the only marks scored in the question. To some extent, success here depended on whether the candidate had come across a similar situation before, or having a sound understanding of the context.

Question 5

Most candidates scored well on this question, even if they left out part (a) and went straight to part (b).

(a) The term for the potential energy of the rod was usually correct, with candidates choosing either C or P as the level of zero potential energy. Most realised that the length AP was needed. Many just wrote down $6a\cos\theta$ but others used cosine rule and quite a bit of working to simplify their answer to obtain $6a\cos\theta$. Using this length to form an expression for the potential energy of the particle proved to be more difficult – some candidates fudged their way to the given answer without considering the length of the string or the distance PC. Candidates who gave a clear indication of their zero level for potential energy were more likely to succeed in reaching the given answer correctly.

(b) For many candidates this was a routine piece of work. The differentiation was usually correct, but when the candidate set their derivative equal to zero to look for turning points it was common to find that the solution $\sin\theta = 0$ was lost in the course of the working. This is a little surprising given that the candidate who pauses to think about the possible equilibrium positions should realise that $\theta = 0$ will be a solution. Despite the fact that they are using calculus with trigonometry and the interval for 2θ is clearly given in radians, several candidates lost a mark for working in degrees. At the end of the question, a small number of candidates lost a factor of Wa in their second derivative or the solutions they obtained from it, losing the final two marks.
There were a few candidates who, having obtained an incorrect expression for the potential energy in part (a), persisted in working with it.

Question 6

This was another question where a clear diagram and labelling was beneficial. It was not always obvious what the candidate was measuring and where from.

(a) Many candidates found the length AP correctly. Most realised that the extensions had to add up to $2a$, but some omitted the weight of the particle from their equation for equilibrium.

(b) It was pleasing to see so many candidates using the displacement from equilibrium correctly. There were a few sign errors in setting up the differential equation, and considerable fudging of signs to reach the given answer. It would have helped if more candidates could have indicated which direction they were taking to be positive at the start of their work.

(c) Candidates who knew that the auxiliary equation would have complex roots usually scored at least two marks here. Having been told that k was positive, they were not expected to say anything about the lower limit, but if they made an incorrect statement they lost the final mark.

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