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June 2011

GCE Mechanics M4 (6680) Paper 1

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June 2011
Publications Code UA028445

Mechanics Mathematics Unit M4
Specification 6680

General

The candidates' responses covered the full range of marks, and it was pleasing to see many concise and elegant solutions to the questions.

In some questions the candidates found themselves short of space. This was often because they started by drawing a copy of a diagram given in the question - they should be aware that they are at liberty to work from the given diagram - the examiner can see the whole of each page of their script.

It was disappointing to find several solutions which started well, but failed due to weak algebraic presentation or arithmetic slips. There was a particular problem over the omission of brackets in expressions, and sign errors when removing brackets.

Candidates need to be reminded of the need to read the question carefully to ensure that they have taken note of all the given information, and that their answer is what they were asked to find. This caused particular problems in question 8, but was also an issue in question 3 and at the end of question 6.

Report on individual questions

Question 1

For many candidates this was a straight forward question to start with. Most errors were caused by sign errors leading to inconsistent initial equations, but some candidates clearly find this topic more difficult when the line of centres lies vertically on the page. Several candidates made no mention of the speed perpendicular to the line of centres immediately after the impact. Those candidates with clearly marked diagrams tended to be more successful. It was disappointing at this level to see candidates trying to substitute vectors rather than scalar quantities into their expression for change in kinetic energy.

Question 2

There were several successful ways to tackle this question. Solutions varied considerably in length, and the more complicated the solution became the less the likelihood of a successful outcome. Those candidates who adopted the method shown in the mark scheme were usually successful, provided they could complete the initial step of dividing their equations to obtain an expression involving tangents. Most alternative approaches formed equations using distance, speed and time parallel to each wall. A few candidates applied the impact law in the wrong direction and were not able to recover from this fundamental error.

Question 3

In part (a) the majority of candidates gave a correct answer here, with just a few finding the velocity of S relative to C instead.

In part (b), those candidates who understood that the velocity of C relative to S needed to be parallel to $\mathbf{i}$ had no difficulty in finding the value of u, and the time taken for C to intercept S, but several did not go on to find the time of the interception.

There were three common methods used in part (c) to find the distance of closest approach. The most popular was the trigonometric method given in the mark scheme. It was usually successful, but does depend on starting with a correct diagram. Also popular was the use of vectors to find the position of C relative to S followed by differentiation of d^2 to find the minimum value of d. The more concise approach employed by some of the stronger candidates was to use the scalar product of the vectors for relative velocity and relative position.

Question 4

Many candidates attempted to draw triangles using the information in the question, but they often made errors in adding the relative velocities. Candidates with a correct diagram were not always able to find the required angle, and there was also some confusion between the direction the wind was blowing from and the direction it was blowing to. Those candidates working from a diagram were usually able to go on to use their angle correctly to find the wind speed.

A common alternative method was to express the given information in vector form, use this to form two expressions the velocity of the wind, and solve the resulting simultaneous equations. This method was longer, but often more successful.

Question 5

Many candidates scored highly on this question. With the given answer in part (a), most candidates who did make errors were able to trace them and correct them. Part (b) proved to be more testing. The majority of candidates started by using $a = \frac{\mathrm{d}v}{\mathrm{d}t}$ and reached an equation involving arctan $\frac{v}{2}$, but several had problems with the constants. Incorrect integration usually involved an attempt to use partial fractions, or the incorrect assumption this was another log integral. It is possible to complete part (b) by using the general solution for v in terms of x found in part (a). A small number of candidates did try this, but none of them got further than setting up a correct differential equation.

Question 6

Part (a) was very straight forward and very few candidates failed to score all four marks. Most errors were due to incorrect signs, often due to poor use of brackets.

In part (b), many fully correct answers were seen, but some candidates made no attempt to set up the auxiliary equation to solve for λ, and there was some confusion due to the minus sign already included in the given form for the solution of the differential equation. Some candidates chose to differentiate the given form twice and substitute this into the differential equation - this was a much longer route, but it worked well provided they made no algebraic slips.

In part (c), most candidates knew that the greatest speed occurs when the acceleration is zero, and they worked through correctly with their solution from part (b). Several slipped up at the final mark because they did not give a positive answer for the greatest speed. A minority of candidates mistakenly believed that maximum speed occurred when $x = 0$, presumably through confusion with Simple Harmonic Motion.

Question 7

In part (a), the majority of candidates understood that they needed to find the elastic potential energy in the string and the potential energy of the two elements of the framework. The question had been set up so that the extension in the string was equal to the distance RB, many candidates used $RB - 2a$ for their extension and spent some time trying to simplify their total to the given form. A disappointing number of candidates struggled because they did not realise that triangle ARB is isosceles. The potential energy of the rod AB was usually correct, and many candidates also had correct expressions for the potential energy of the rod BC. A few candidates offered no attempt at all to this part of the question.

Many fully correct answers were seen in part (b). Most errors were due to slips in the differentiation or confusion between $\cot 2\theta$ and $\tan 2\theta$.

Part (c) was well answered, but there were a few errors in substituting for 2θ and some candidates simply stated that the equilibrium was unstable without offering any justification.

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