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Examiners' Report

Summer 2014

Pearson Edexcel GCE in Mechanics 4 (6680/01)

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Mathematics Unit Mechanics 4

Specification 6680/01

General Introduction

The majority of the students for this paper showed a good command of the whole of the specification - they offered responses to all of the questions, and much of the work was completed to a high standard. However, there was a minority of students for whom work at this level was either not sufficiently well prepared or too demanding.

The best work was clearly set out, and accompanied by clearly labelled diagrams. Students should be reminded of the need to make their work clear to the examiners - some handwriting is so small that it is difficult to read. It would be helpful if students took more care in writing figures - there needs to be a distinction between 4 and 9, and it is common to see students miscopying their own 3, 5 and 8.

When an expression or equation is given in a question, the students should be advised not to overrule the examiners by using their own alternative version. No marks will be earned for solving the wrong equation.

Students need to be reminded to read the rubric and the questions very carefully. In all cases, where a value for g is substituted, the value should be $9.8ms^{-2}$. The use of 9.81 will be penalised as an accuracy error. The rubric on the paper gives students a very clear reminder about the accuracy expected after the use of 9.8, but many students lose marks for giving too many significant figures in their final answers.

Report on Individual Questions

Question 1

Most students made good progress with this question. Both differentiation of the square of the distance and use of the scalar product were popular methods. Unnecessarily taking the square root before differentiating created problems for some students.

Some students tried to reverse the problem by using the given answer to find the time at which this occurred; this approach usually failed to show that a minimum distance had been obtained.

A minority of students wrote down the position vectors of the particles but made no further valid progress. Some attempted a scalar product of vectors which were not relevant in this context, and occasionally only the initial distance between the particles was calculated.

Question 2

In Q02(a) virtually all students produced an equation of motion and deduced the value of the acceleration correctly. However, since the answer was given it was important that the substitution of $v = 20$ was actually seen in order to earn full marks.

In Q02(b) most students produced a correct differential equation in terms of v and x, and separated the variables correctly. Several entirely correct solutions were seen, but many students could make little valid progress with the integration of $\frac{v^2}{2500 - v^2}$. Although there were a variety of possible approaches (partial fractions, use of the arctanh or the logarithm formula from the formula book, or substitution) most required division or re-arrangement first. Some attempted partial fractions with the expression unchanged and some just wrote down a logarithm term. Those who adopted a valid method sometimes lost accuracy marks through sign errors or losing/gaining a zero in the numerical terms.

It was obvious that some students were using numerical integration on calculators - this is very risky - an incorrect final answer (which was common), with no working shown, will lose all the marks.

Question 3

Most students correctly identified the components of the velocity (before and after collision) perpendicular and parallel to the wall, and wrote down two equations relating them, usually in terms of trigonometric ratios of the two angles. With no guidance on what to do next, several students made no further progress. Among those students who did square and add their equations to obtain a correct ratio, there was some confusion about where the angle of deflection is - only the more able students knew that it lies between the continuation of the initial direction of motion and the final direction of motion.

Question 4

In Q04(a) most students drew an appropriate vector triangle and used the sine rule to find a relevant angle. The standard of diagrams presented was sometimes very poor - the diagrams were too small and the angles involved far from clear, leading to errors in subsequent calculations. Having found a relevant angle, some students made errors in calculating the bearing. Students should take note when a question specifies a level of accuracy – in this case they were asked for an answer to the nearest degree.

In Q04(b) many correct solutions were seen - the majority of students continued with their vector triangle. Students completing the work on several stages need to be aware of the risks of errors in the final answer through premature approximation.

Some chose to work in components throughout this question, either parallel/perpendicular to relative velocity, or 'N' and 'E'; sometimes they were successful but some were not able to handle the resulting equations properly.

Question 5

In Q05(a) although the majority of students produced appropriate momentum and restitution equations, the directions of their velocities were often not well defined nor clearly shown on a diagram. This led to frequent sign errors. Mistakes in solving the resulting simultaneous equations were quite common.

The definition of impulse was generally known but occasionally speeds rather components of velocity (or a mixture of the two) were used.

In Q05(b) there was confusion between speeds and components of velocity in the calculation of kinetic energy. Although it was not necessary to find the perpendicular components in finding the loss in energy, it was necessary to use the whole speed in the calculation of initial energy. Some found the final energy (rather than loss) as a fraction of the initial energy, and occasionally the energies for both spheres were combined. Some students used $\frac{1}{2}mu^2$ in place of $\frac{1}{2}m(3u)^2$.

Question 6

In Q06(a) a small number of students secured all three marks. Although almost all knew the terms could be derived from the equation of motion, few handled the signs of these correctly. The best way to demonstrate the result was to start with a clear diagram showing the directions of x, $\dot{x}$ and $\ddot{x}$ and the corresponding directions of the tension and the resistance. Some students obtained an equation of motion with different signs from those given, and a few persisted with the wrong signs in Q06(b).

In Q06(b) many students solved the differential equation correctly to find x in terms of a and t. Most errors were due to the use of incorrect initial conditions (commonly $t = 0,\ x = 2a$), and in a few cases students had an incorrect solution for the auxiliary equation.

In Q06(c) most students realised that the string was slack when $x = 0$. Although a number of students correctly found that $\tan t = -\frac{1}{2}$, some substituted a negative value of t to find the speed. Some students overlooked the fact that they had been asked for the speed, not the velocity.

Question 7

In Q07(a) since the expression for the potential energy was given, it was important that this was derived clearly and correctly. Almost all knew and applied the formula for elastic potential energy although not all could relate 'x' to the angle defined in the diagram. It would make the working clearer if an initial statement of the position of the zero P.E. level were given. It would also help if students did not omit constants between lines of working and carried them through to the final line. Sometimes this part of the question was omitted or abandoned fairly quickly.

In Q07(b) most students differentiated correctly and set the derivative equal to zero to investigate the equilibrium positions. There were three possible angles: $\pm 0.72, 0$; some identified one or two of these, but often not all three. Many spurious angles were found which bore no physical relation to the problem. Again, most found the second derivative to identify the nature of the equilibrium positions. However, it was important that no terms were dropped when investigating the sign and that the actual values were stated in support of the conclusions.

Grade Boundaries

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