Examiners' Report
Principal Examiner Feedback

Summer 2017

Pearson Edexcel GCE
In Mechanics M4 (6680/01)

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Introduction

This paper proved to be very accessible to those candidates who had studied all the topics examined. There were some questions; Q2 (oblique impact of particles), Q4 (oblique impact with a plane) and Q5 (relative velocity), which although not intrinsically difficult posed more problems for candidates than usual. This was balanced by Q6 (damped harmonic motion) and Q7 (potential energy), which were routine questions of their types, in which most of the marks were available to the majority of candidates. The majority of candidates offered responses to all questions. However, there were several candidates who declined to offer solutions to certain types of questions, most notably the relative velocity, and questions described using vectors - these candidates are limiting the maximum marks available to them.

The best work was clearly set out, and accompanied by clearly labeled diagrams. Candidates should be reminded of the need to make their work clear to the examiners, there is no need to fit a three-component column vector in the space between two lines. It would be helpful if candidates took more care in writing figures - there needs to be a distinction between 4 and 9, and it is common to see candidates miscopying their own 3, 5 and 8.

Candidates 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 9.8 m s^{-2}. The use of 9.81 will be penalised as an accuracy error. The rubric on the paper gives candidates a very clear reminder about the accuracy expected after the use of 9.8, but many candidates lose marks for giving too many significant figures in their final answers.

Question 1

(a) Most candidates found the relative position vectors of the ships correctly and formed an expression for the square of the distance between them. They then found the time for which this distance was a minimum. The use of the scalar product method was a popular alternative, and a few candidates used trigonometric methods. Some candidates who found the correct value of t did not go on to give the time of closest approach.

(b) The simplest approach, adopted by the majority of candidates, was to use the quadratic in t found in part (a) to form a quadratic inequality and find the difference between the roots. There were many correct solutions although accuracy was sometimes a problem. Methods using trigonometry were rare, but often successful.

Question 2

The responses to this question underline the need to read questions carefully and to use clear diagrams.

(a) This was often made more difficult by poor diagrams and ill-defined components of velocity after collision. Some candidates were confused by the line of centres of the spheres being parallel to **j**. Some set about describing the components of the velocities after the collision without noting that the components in the **i** direction were 5 and 3, so they created more unknown variables than necessary. In forming the equation for the kinetic energy, several candidates used 85% of the total initial kinetic energy, rather than using B only, as described in the question. The majority of candidates who obtained $v^2 = \frac{49}{4}$ did select the correct component, $-\frac{7}{2}$. However, some candidates

selected the wrong root and did not seem to notice that in their solution the spheres had passed through each other.
(b) The impact law was usually stated correctly but the signs of the components caused problems in some cases.

Question 3
This question was a good source of marks for many candidates. The equations of motion in both parts were almost always correct.
(a) The standard method of separating the variables was well known and applied well. A small number of candidates solved this using the integrating factor method. There was a marked reluctance to simplify the equations by dividing through by the common factor of 3. A few candidates did not go on to find v in terms of x.
(b) Several candidates turned to the formula sheet for assistance with the integral, with many solutions involving $\operatorname{ar}\tanh\frac{v}{\sqrt{50}}$. Those candidates who had retained the common factor of 3 often had difficulty in adapting their answer to take account of the $\sqrt{3}$ now involved.

Question 4
Vector methods using scalar products with vectors along or perpendicular to the plane produced elegant and simple solutions to this question but were only attempted by a small minority of candidates.
(a) This application of conservation of momentum parallel to the plane proved elusive for many candidates. A popular equivalent approach was to use the fact that the impulse is perpendicular to the plane. Many tried a trigonometric approach but poor and confusingly labeled diagrams caused problems in identifying the correct angles.
(b) Candidates were more successful in this part; using the given value of a, they were able to find components of velocities perpendicular to the plane and hence find the value of e. Several attempts demonstrated that candidates understood the basic principles, they set up correct equations, but could not solve them.

Question 5
This question proved difficult for many candidates. Although there was some evidence that candidates were familiar with relative velocity, that rarely translated into coherent diagrams that could lead to correct answers. Manipulating the given information caused problems. A method often seen with a good diagram was to use the sine formula in both triangles and eliminate the speed of the wind to find an angle. Many found the direction in which the wind was blowing, but not the direction from which it was blowing, as requested in the question.
The alternative method of forming two different vector expressions for the velocity of the wind and equating components of the two vectors was not common, but was usually successful.

Question 6
(a) This was a standard problem on which many candidates scored well. However, there were a number of attempts which ignored the equilibrium position entirely or merely stated that the measurement from the equilibrium position cancelled out the weight of the particle. Many candidates were confused about the direction in which displacement, x, was measured as positive and consequently the signs of the

acceleration and the resistance terms. Some candidates resorted to calculating the tension with $e - x$ rather than $e + x$ in an attempt to reach the required answer.
(b) The standard method for solving a 2nd order differential equation was well known and usually applied proficiently, although the values of the arbitrary constants were not always found accurately.
(c) Most candidates indicated an intention to solve $\frac{\mathrm{d}x}{\mathrm{d}t} = 0$ but inaccuracies in the arbitrary constants found in (b) often led to equations they could not solve.

Question 7

(a) This part of the question was open to manipulation to achieve the given answer. Some candidates assumed that the given answer was incorrect, and some did not justify the " + constant" in the given answer.
(b) Apart from a few errors in the coefficients, this was answered well by most candidates.
(c) Again, this was answered well by most candidates, with just a few candidates not considering all factors of the second derivative in reaching their conclusion.

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