Examiners' Report

Summer 2015

Pearson Edexcel GCE in Mechanics M1 (6677/01)

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Mathematics Unit Mechanics 1

Specification 6677

General Introduction

The vast majority of students seemed to find the paper to be of a suitable length, with no evidence of students running out of time. Students found some aspects of the paper very challenging, in particular questions 4, 5(b) and 8(b). However, there were some parts of all questions which were accessible to the majority. The first question on momentum and impulse, question 2 on free motion under gravity and question 3 on equilibrium under three forces showed that the relevant mechanics principles were well-understood.

The vector question was also completed well by many students and an encouraging number secured full (or almost full) marks for Q8(a) which was an unstructured question involving a pulley with one of the particles moving on an inclined plane. The paper discriminated well at all levels including at the top end and there were some impressive, fully correct solutions seen to all questions. Generally, students who used large and clearly labelled diagrams and who employed clear, systematic and concise methods were the most successful.

In calculations the numerical value of g which should be used is 9.8, as advised on the front of the question paper. Final answers should then be given to 2 (or 3) significant figures – more accurate answers will be penalised, including fractions but exact multiples of g are usually accepted.

If there is a printed answer to show then students need to ensure that they show sufficient detail in their working to warrant being awarded all of the marks available.
In all cases, as stated on the front of the question paper, students should show sufficient working to make their methods clear to the Examiner.

If a student runs out of space in which to give his/her answer than he/she is advised to use a supplementary sheet – if a centre is reluctant to supply extra paper then it is crucial for the student to say whereabouts in the script the extra working is going to be done.

Report on Individual Questions

Questions 1

Overall this was a well-answered question and got the students off to a confident start. In the first part the vast majority of students was able to write a correct equation using Conservation of Linear Momentum and this led, for most, to the correct value for the unknown *k*. Errors tended to occur because of algebraic slips or, slightly more commonly, through careless cancelling in omitting to cancel elements from one of the terms. Too frequently '*u*' was being dropped and replaced by its coefficient. At this level, it is to be hoped that students, when checking answers, would recognise that each term here should be of the same form and, if this was not the case, to do something to rectify the matter. Less popular was to equate the impulses on the two particles; the major disadvantage here is that errors in impulses are more common than with momentum and thus, the method gives students greater opportunity to make mistakes.

In general, the CLM approach was done well and it may be that having two particles moving in opposite directions before and after the collision leaves less room for careless errors. Part (b) was a very familiar follow-up to the first part with many reaching the correct answer quickly and efficiently. However a sizeable minority were unable to deal successfully with subtracting two momenta of different signs although it was evident that almost all knew that the two momenta had to be subtracted. If '*m*'s or '*u*'s were omitted or 'cancelled' the answer was not an impulse and all marks were lost. There was still a significant number who gave a magnitude as a negative quantity and lost the final mark.

Question 2

Part (a) caused very few problems with nearly all students getting the correct answer. Most errors were arithmetical or sign errors. The second part was far more problematic, with a number of different methods being used. The direct approach was generally the most successful, although many forgot or didn't realise that they needed to find the difference in the times to earn the final mark. When the velocity at a height of 14.7 m was found, students were far more likely to get confused over initial/final velocities, although many did manage to get to the correct answer. It was disappointing to see how many failed to realise that they could just double their answer and instead chose (generally different approaches!) to find an upwards and downwards time. Some students seemed unclear as to which part of the motion they were dealing with eg using $19.6 = 19.6t - \frac{1}{2} gt^2$. A few simply found the time to the maximum height. The quadratic formula was the most common approach to solve the resulting quadratic, with relatively few students spotting the common factor and straightforward factorisation. Others used their calculators so lost the method mark if incorrect solutions were found.

Question 3

For the most part students gained the method marks for this question, although the accuracy marks were often lost. The most popular approach was the main markscheme method and in spite of some odd decisions to label the strings the wrong way round most were able to get the resolving correct. This method did involve the most difficult manipulation and many managed to drop trigonometric terms, leading to two incorrect answers. The most common error in eliminating one of the tensions appeared to be forgetting to multiply by the correct trig ratio when substituting

eg $P = Q\cos35/\cos55$ was substituted into $P\sin55+Q\sin35=2g$ but then $\sin55$ was forgotten, giving $Q\cos35/\cos55 + Q\sin35=2g$. Sadly too many who did get to the correct answers then gave too many significant figures and lost a mark. When attempting the alternative methods it tended to be all or nothing (apart from over accuracy). Resolving along the strings was reasonably popular and the trigonometry was nearly always the correct way round. All examples attempting to use either the sine rule or Lami's theorem tended to be correct.

Those who noticed that there was a right-angle involved were able to gain all 7 marks in just two lines of work by resolving along each string and were very clear and concise in their work. It was rare to find students assuming the tensions to be the same.

Question 4

This question proved to be a real discriminator with many failing to appreciate how internal and external forces work, it was not unusual for students to produce incorrect equations and score zero marks for the whole question. Future students would be advised to spend time analysing lift systems and practising writing down the equations of motion for each part of the system. In part (a), the motion of the lift was attributed with two unknown quantities and hence the first part of the question could only be done in one stage by considering the forces acting on the crate. Students able to arrive at the correct value for the acceleration were very much in the minority. The second part could be done without using the answer to part (a), and most successful attempts came from using a whole system equation. Those who used an equation for the lift only, tended to be unsuccessful. Having arrived at the correct answer, a good proportion then forgot that this question involves the use of g and neglected to write the final answer to either two or three significant figures thus losing the final mark. Other errors usually involved the omission of m from one or both terms, mixing the two masses and including an extra g in all of the terms.

Question 5

In part (a) the vast majority of the cohort was able to score well on this very standard problem. Apart from the occasional minor arithmetical slips, most were able to produce a vertical resolution and to take moments about *A* or *C*. Those who took moments about *C* were at a slight disadvantage as there was a higher probability of a sign error in this situation. Most students were able to produce correct solutions for the tensions although once again, many lost a single mark through over-accuracy in a problem involving *g*, for giving answers to more than 3 significant figures. In the second part of the question many students failed to appreciate the significance of being asked to find the *greatest* possible values of *M* and *Tc*. Those who did analyse the situation successfully were able to gain easy marks but the sizeable majority went around and around in circles trying to deal with the problem of an extra variable. This type of problem emphasises the key importance of thinking clearly about the specific physical situation before embarking on the force diagram. Once again, the answer was obtained using *g* and a few students lost a mark for giving the answer to more than 3 significant figures.

Question 6

In part (a), the vast majority of students identified correctly the initial position vector. Most were able to equate one (or both) components to calculate the required time in the second part. Some who attempted to find the ratio of the displacement vector to the velocity vector gave an answer for *T* (time) as a vector (for example 3.2**i** + 3.2**j**), showing a lack of understanding of vector quantities. There were two main alternative approaches to completing part (c). Those who identified **v** = 2**i** - 5**j** from the given expression almost invariably went on to use Pythagoras correctly to find the required speed. However, those who attempted a distance (or displacement) divided by a time tended to be less successful; errors seen included using the wrong displacement (in particular the given 3.4**i**-12**j**), or confusing displacement and velocity. Occasionally, the velocity vector 2**i** - 5**j** , rather than the speed, was given as the final answer, but such cases were relatively rare and many fully correct solutions were seen. Full marks for this question were rare with a significant number of students achieving little or no credit.

Question 7

In the first part the graph was nearly always correct with *V* marked, although, many of the graphs seen were symmetrical but this wasn't penalised. The majority were able to score some marks in part (b), although a huge number seemingly were unable to deal with $^{V}/_{0.5}$, etc.... Many got confused with minus signs for the deceleration and another common mistake was to find the time at which deceleration began, rather than the time of deceleration. Most had an idea of how to find the time at constant speed but a significant number seemed to want to use *suvat* somehow and a small number forgot to convert into seconds. In part (c) most seemed to know that they had to use the area under their graph, but some did not manage to find times in terms of *V*, and therefore made no progress. There were many ways of losing accuracy, either through mistakes made in part (b), failure to correctly collect terms or the use of 6.3 instead of 6300. The mark scheme was actually very generous to them, allowing follow through marks for some pretty horrible algebra in part (b). Although the most popular approach was to find the three areas separately, those that chose the trapezium approach were generally more successful, with less opportunity for slips. Unfortunately, many did not give a clear method for solving their quadratic, which given the large number of incorrect equations, lost them the M mark. Those that got through to the correct two answers nearly all clearly stated that $V=30$, although some decided to go for 70.

It was interesting to see how many failed to simplify their quadratic equation and how few students were able to factorise into two brackets. The majority went straight to the quadratic formula despite the equation being fairly straightforward.

Question 8

This was an unstructured question but a fairly familiar scenario. It involved setting up equations of motion (one vertical and one parallel to the inclined plane) for the two particles and then solving them (by eliminating or finding the acceleration) to find the value of the tension. Most students gained marks for correctly calculating the normal reaction and using this to find the frictional force. The most common error was in the sign of the friction term in the 'parallel' equation, possibly a result of misinterpretation of direction of motion. There were some instances of omitting a force term completely, sin/cos confusion or including '*g*' in the '*ma*' term. Occasionally the acceleration was not taken into account at all which led to oversimplification of the problem and consequently a significant loss of marks. Those who set up their equations correctly sometimes made numerical or processing slips in solving them, thereby losing the final mark in part (a). Nevertheless, an encouraging number of fully correct solutions were seen, with the final answer being rounded to 2 or 3 significant figures (following the use of $g = 9.8$), or given as ' $2/3\ g$'. Students generally seemed less familiar with an appropriate method for finding the resultant force exerted on the pulley by the string, as required in part (b). Some omitted it completely, or used forces other than the tensions. The most common successful approach was to resolve the two tension forces in the direction of the resultant which by symmetry is along the angle bisector, although the required angle was not always identified correctly with some using $2T\cos(\alpha/2)$, or even $2T\cos 45$. The use of the cosine rule was an alternative method but again sometimes the wrong angle was used. Those who found a component only in either the horizontal or the vertical direction received no credit; however, those who proceeded to square and add both the components tended to do so correctly and achieve full marks. If an incorrect value for the tension was carried forward from part (a), three out of the possible four marks were available.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:
http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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