Examiners' Report/
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June 2011

GCE Mechanics M3 (6679) Paper 1

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Mechanics Mathematics Unit M3
Specification 6679

Introduction

Once again much work of a high standard was seen although errors which should not be made by Further Mathematics candidates were also seen. The standard of solution of simultaneous equations was poor. Many of the algebraic errors were of GCSE or earlier standard - moving terms from one side of an equation to the other without changing sign, dividing when addition or subtraction was required and multiplying only some of the terms in an equation when removing fractions.

Candidates never give questions involving inequalities the attention they deserve, frequently setting out to solve an equation and deciding later to change a suitable sign which will produce the right answer. They would be well advised to consider how an inequality might arise before doing anything else at all. Working with an inequality throughout is likely to earn more marks. Starting with an equation means that an assumption has been made - this is rarely stated - and changing the equality into the required inequality can be very difficult to justify satisfactorily. In fact candidates rarely attempt a justification at all.

Crossing out work in a manner which means that examiners cannot read the crossed out work is inadvisable as occasionally the work may generate some marks.

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. If there is a printed answer to show then candidates 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, candidates should show sufficient working to make their methods clear to the Examiner. If a candidate 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 candidate to say whereabouts in the script the extra working is going to be done.

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Report on individual questions

Question 1

For the majority, this was an easy starter to the paper. Most candidates were able to make a good attempt at applying Newton's Second Law with the correct form of the acceleration. A few omitted the minus sign; if candidates realise they have made a mistake they should ensure that they go right back to the beginning to correct their working otherwise they will forfeit marks.

Part (b) was nearly always correct. The most common error was to find $\sqrt{470}$ rather than $\sqrt[3]{470}$ and there were a few rounding errors.

Question 2

The vast majority of candidates knew the correct formula and were able to calculate the relevant integrals. A few used the formula for a lamina instead and a few were unable to square the brackets correctly. Nearly everyone used π either consistently or not at all and candidates usually scored full marks. Candidates who use calculators to evaluate definite integrals should be aware that if their answer is wrong and they have not shown any working, they will lose many marks.

Question 3

The main problem with part (a) was that many candidates did not set out their work clearly – often the point from which they were measuring the centre of mass was not specified and the volume and hence mass ratios were not always simplified. This led to some candidates becoming confused and losing marks. A small minority used density rather than mass ratios and others who obtained a negative answer forgot that a (positive) distance was required. Those who chose to measure from the base of the solid avoided problems with signs and almost always obtained the correct final answer but some forgot to complete their work.

Part (b) was answered well with candidates who had made a mistake in part (a) able to score three of the four marks. Some candidates would have benefited from drawing a clear diagram with lengths and angles marked because they used the wrong lengths in their tangent ratio.

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Question 4

There were some fundamental errors in part (a) – having the same tension throughout the string, not recognising that the lower triangle was isosceles, thinking that the angle at P was a right angle and that the angles in the two triangles were the same. It was also a test of skill in algebraic manipulation. Most candidates resolved correctly in two directions and substituted for sine and cosine straight away. Some then realised that adding the two equations led almost immediately to the given answer while others, particularly those who had not substituted, spent a page or two and valuable time doing complicated rearrangements which often eventually led to the correct answer. Candidates who mixed up their sine/cosine resolutions obtained the correct answer from wrong working but part (b) was then incorrect. These candidates also lost accuracy marks in part (a).

Part (b) was also a severe algebraic test for some and candidates did not always collect the terms in their answer – something which is expected at this level. There was a hint about the final form as it should have been similar to the given answer in part (a). If the expression was simplified and factorised, part (c) became much easier.

In part (c) a small minority did not realise that the tension in the lower string had to be greater than or equal to zero and used the difference in the two tensions. Those who had the correct answer in part (b) usually scored the last two marks.

Question 5

Part (a) highlighted the difficulty many candidates have in setting out a plausible proof, especially when an inequality is involved. All too often the tension in the string was correctly equated to the frictional force, which was then incorrectly stated to be equal to μR. Given that $F \leqslant \mu R$ is also regularly examined in M2 this showed a poor understanding of friction forces. Once $\mu = \frac{1}{2}$ had been obtained it was common to see the required inequality appear. Sometimes an attempt to explain the inequality was given, but only in rare cases would this be satisfactory.

Most attempted parts (b) and (c) using the change in energy, successfully equating elastic potential energy, kinetic energy and work done against friction although there were some sign errors in the equations. However, many omitted the work done against friction from their calculation, in spite of the attention drawn to friction by part (a). Those who attempted to use the equation of motion had more success in part (c) when they could consider the motion after the string had become slack hence constant deceleration applied. Too often the attempts in part (b) had T as a fixed value, rather than involving x, so no solution of a differential equation was attempted. Some candidates attempted an SHM solution. The majority of these were aware that the centre of the motion was where the extension was $\frac{1}{6}l$ and set up their equation accordingly although again some assumed that T was constant. Candidates adopting this approach must be careful that they prove that the motion is simple harmonic while the string is stretched.

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It was surprising how many candidates who had omitted friction from their attempt at part (b) then included it in part (c). This did, however, allow them to gain some of the marks for (c). The most common error in (c) was to obtain the distance moved after the string became slack and forget to add $\frac{1}{2}l$.

Question 6

In part (a) there was a distinct lack of appreciation of motion in a vertical circle using a string and hence the need to find the tension in the string. Candidates should realise that two lines of work (one equation) would not justify 6 marks for this part but many gave $v = \sqrt{7ag}$ as justification for the particle passing through B. Of those who considered the tension, the vast majority got full marks, and most included a final written statement. Quite a few ignored the fact that all the asked-for positions were easy and chose a general position for their equation(s) in (a); these nearly always wrote down both the equations, suggesting that this was a memorised method. Answers to (a) and (b) then followed very easily by substituting suitable values for θ but, taken as a whole, this was an unnecessarily time-consuming method.

Most knew that the principle of conservation of energy should be used when considering this type of motion and they applied it very successfully in parts (b) and (c). A few made errors with the heights when calculating the potential energy. A surprisingly large number worked from B to C rather than A to C. fortunately, most had a correct expression for the speed at B and so this approach did not jeopardise their result for (b).
Some candidates seemed to be distracted by the mention of an impulse in part (c) and tried to relate $I = mv - mu$ to their solution; these candidates usually then gave up Others showed the correct use of an energy equation by showing the correct height, but then went on to find the wrong angle. Many used simply *mgh* in their energy equation and sorted out the trigonometry afterwards, almost always successfully, but a few drew an incorrect triangle and used a tangent calculation (the remaining height $\frac{13a}{288}$ being shown with a correctly placed angle but an opposite side of length a).

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Question 7

In parts (a), (b) and (c), although the question was laid out to allow sensible working through to a standard solution for SHM, many candidates still made basic errors in their working. Parts (a) and (b) required Hooke's Law for two separate strings, as the tensions in the two parts are different (as suggested by the question asking for each tension to be found). Hence $l = 0.7$, not 1·4, and an extension using "final length – l" were needed. A few realised that, for part (b), the answer could be written down by simply changing the sign of the answer for (a) but most repeated their previous calculation with a different extension.

Part (c) was often done entirely using "a" for acceleration instead of the differential form, and the minus sign was slipped in late (or occasionally left out altogether) when $T_a - T_b$ was used for the resultant force.

The fact that ω could be deduced from the given result in part (c) allowed many to produce correct answers for parts (d) and (e) even when they had not been successful earlier. Nearly all who attempted these parts quoted correct general forms of the results needed ie $v = a\omega$ in (d) and either $x = a\cos\omega t$ or $x = a\sin\omega t$ in (e), applying them well to the specific motion as required. Some candidates however were unable to deduce the correct time from the solution of their trigonometric equation. It was not uncommon to see candidates who thought that $x = a\cos\omega t$ with $x = 0.1$ would give them the time from O to D. A few candidates forgot that radians are required when working with SHM. Reference circle attempts seemed more common than usual but were not particularly successful. Candidates did very well in finding an angle but often didn't know how to use it to obtain the required time.

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