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GCE Mechanics M3 (6679) Paper 1

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Mechanics Mathematics Unit M3
Specification 6679

Introduction

As ever, the gulf between the best and worst was very wide with some candidates making errors that should not be seen on a Further Mathematics paper. The application of calculus in questions 3 and 5 was relatively weak while the more formulaic questions (2, 4 and 7 in particular) were generally well done.
Most candidates seemed to have sufficient time to complete the paper. Although there were a few unfinished final questions these seemed mostly to have run out of ideas rather than time.
Again as ever, it is incomprehensible that some candidates take so little care over the presentation of their solutions. The best are well set out, logically explained and show detailed calculations but others are scribbled and messy in barely legible handwriting. Candidates would do well to remember that examiners cannot give marks when they cannot read the work.
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.

Question 1

This was intended to be a straightforward opening question which would give candidates confidence to proceed with the rest of the paper. The majority of candidates no doubt thought they had answered it correctly. However many failed to realise it was an elastic energy question instead treating it as an equilibrium of forces problem putting $T = mg$ at the lowest point. Those who recognised it as an energy question rarely lost any marks; the EPE formula was well known and the straightforward energy equation easily solved. The only recurring error, following careless reading of the question, was to assume that the particle fell from the natural length of the string rather than the full height.

Question 2

The basic results for SHM were well known and invariably quoted correctly hence most candidates had $\omega = 3$ even if a numerical mistake occurred later in their working. Some did the working for part (c) to find a value for t before answering parts (a) and (b) with $\ddot{x} = -a\omega^2 \sin \omega t$ and $\ddot{x} = -a\omega \cos \omega t$. In (a) some candidates failed to give the magnitude of the acceleration while others did not give a suitable description of the direction. "Opposite to the direction of motion", “Backwards”, “Away from O” (there wasn’t an O!) were all seen many times. There were, inevitably, a few very weak attempts at the whole question, featuring misquoted formulae in (a) and (b) and attempts to do (c) by assuming that distance and time were proportional. The reference circle approach to (c) was comparatively rare and not usually well done; they had difficulty identifying the correct angle. As always some candidates failed to change the mode of their calculator from degrees to radians.

Question 3

In part (a) there were several variations on an expression for the acceleration, some of which were incorrect. Many used $a = \frac{dv}{dx}$, some wrote $a = \frac{dv}{dt}$ but calculated $\frac{dv}{dx}$ and others used $\frac{d\left(\frac{1}{2}v^2\right)}{dx}$ and these mainly obtained the correct answer. Those who used the anticipated $v\frac{dv}{dx}$ were usually able to complete the solution successfully. There were some problems with the differentiation, with some candidates being unable to deal with negative powers correctly which is very disappointing at this level.

Part (b) was more straightforward and there were many completely correct solutions. Some candidates were unable to separate the variables and $\ln(x+6)$ was then seen. Most candidates preferred to use indefinite integration.

Question 4

Part (a) was generally answered very well with Hooke’s Law and the resolving done correctly. There was sometimes a lack of clarity in the processing of the two equations with unnecessary and muddled working frequently seen. A few candidates had not read the question properly and used 60° as the angle with the horizontal.

In part (b) some candidates used r = 0.8 instead of $r = (0.8 + 0.4)\sin 60^\circ$. Those who resolved T correctly and cancelled the $\sin 60^\circ$ usually reached the correct answer. Unfortunately many either omitted it on one side or did not see that $\sin 60^\circ$ would cancel and worked out all the numerical values - this meant that some lost the last A1. A few left their final answers in terms of m – when values are given in the question they must be used.

Question 5

Candidates need to be careful in "show" questions like part (a) that they write down a convincing argument. There were many candidates who failed to use R and x appropriately at the start and tried to correct themselves at the end with no clear reason as to why their x became $R+x$. Many tried to reproduce a memorised proof that they clearly didn't understand. They knew that *mg* and *R* were significant in finding k but failed to introduce them together; so $mg = \frac{k}{(R+x)^2}$ or $mg = \frac{GMm}{(R+x)^2}$ were not uncommon as first statements. Others simply stated, without any attempt at a reason, that $k = mgR^2$; probably they deduced this from the result they were trying to derive.

In part (b), quite a number of candidates failed to see the need for the use of an integral as the acceleration was a function of x in whatever method they used.
Those who treated it as a variable acceleration problem generally obtained good results, even if some errors were made in their work – the main one being the wrong sign, with occasional poor integration and general algebra when substituting the limits. The majority opted to treat it as an indefinite integral. As with part (a), some candidates chose to work with x as the distance from the centre of the earth rather than $R+x$ as given in the question. Most changed the limits to $2R$ and $3R$ and so had effectively made a linear substitution. Quite a number used the work-energy principle and the vast majority who correctly used an integral got good answers; unfortunately many failed to realise that an integral was required, instead using mgh as the GPE at all the relevant points. There were also more than a few attempts to use $v^2 = u^2 + 2as$, with an acceleration found by using either $x = R$ or $x = 2R$ in $\frac{mgR^2}{(R+x)^2}$. A few used this same constant value of the acceleration to set up a differential equation; some of these may even have qualified for a mark or two before their major mistake.

Question 6

This question was probably the most difficult for candidates. The energy equation in part (a) was set up with two KE terms and one GPE term but a common mistake was to use $mgl\cos\theta$ instead of $mgl(1-\cos\theta)$. The resolution towards the centre was usually correct, with the omission of the weight term being the only error. Those who had written the two equations correctly, (as well as some who had not) went on to obtain the given answer.

The first mark in part (b) followed from the answer to part (a) but a few started again with an energy equation. Most used energy to find *v* but the easier option was to go back to the equation for T, setting $T = 0$ and $\cos\theta = -\frac{1}{4}$.

Very few correct solutions were seen for part (c). Some used conservation of energy forgetting that there was KE at the top. Others used equations of motion vertically but forgot to resolve the velocity. For those who did resolve, there was some difficulty in finding the angle with the vertical – they often used numerical values rather than relating it to the $\cos\theta = -\frac{1}{4}$ obtained in part (b).

Question 7

Part (a) should have been a straightforward application of the result for calculating the centre of mass, and many candidates produced impressive solutions. However too many candidates were let down by mistakes with basic algebra and integration. There was plenty of scope for arithmetic errors when substituting the limits, so candidates would be well advised to show some intermediate steps in their calculations - method marks for an incorrect solution can only be awarded when the method is made clear to the examiner. A few showed some incorrect working and then simply wrote down the given answer in the hope that the examiner would not notice. Others did not complete their correct work as they realised their working was not going to yield 1.42 and had forgotten that they needed to subtract 2 as a final step.

In part (b), most candidates knew that the centre of mass had to be directly above the lowest point of contact, but many mistakes were made in the incorrect value of radius being used, usually 2 instead of 4 and in finding the wrong angle by having the fraction upside down.

Part (c) seemed to be better but by this stage there was some scrappy work and the resolutions and equations were not always presented clearly. However, the correct answer was obtained by the majority of those who attempted this part as the shape was irrelevant for correct answers here since β only relied on the value of μ.

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