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Examiners' Report

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GCE

Mechanics M3 (6679)

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Introduction

This seemed to be a well-balanced paper with a reasonable number of accessible marks for the E grade candidates and plenty to challenge the A grade candidates too. The solutions for Q7 did not suggest that candidates had insufficient time to show what they could do on the paper. There seemed to be many well-prepared candidates but also a significant number who had no idea how to tackle some of the topics and made errors at M1 level. Some candidates feel they can answer questions by quoting results. Obviously set principles are involved but mistakes, with consequent loss of marks, still occur from candidates not really interpreting the question set and believing a quoted answer would cover the mechanical principle. This happened in Q1, Q7 and particularly Q5, where the angle θ was defined to be an angle with the horizontal instead of the more usual vertical.

Some very poor handwriting was seen and in some cases candidates appeared to be unable to read their own writing. Careless writing can lead to errors. In Q2(a), the π in the expression for a sometimes wandered from the denominator to the numerator of the fraction, with consequential accuracy errors in the following work. Also in Q2, some candidates used n instead of ω and their handwriting made it difficult even for them to distinguish n from π. Square root signs are not always written carefully. For example, in Q7(b), $v = \sqrt{\left(\frac{8ag}{3}\right)}$ or $v = \sqrt{\frac{8ag}{3}}$ are correct but $v = \frac{\sqrt{8ag}}{3}$ is not, even if the latter is preceded by $v^2 = \frac{8ag}{3}$. Similarly, $\sqrt{(6ag)}$ and $\sqrt{6}ag$ are not equal.

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 once per question. Candidates should also be aware that marks are usually only given for work that is in the appropriate part of the question.
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.

Report on individual questions

Question 1

This was a straightforward non-uniform motion problem and so made a good opening question for the paper. Nearly all candidates set up a correct differential equation and attempted the required integration. Inevitably some integrated their acceleration as $\frac{1}{2}v^2$. Most who made this fundamental error had not previously written the acceleration in its differential form; had they done so they would probably not have chosen $v\frac{dv}{dx}$ and so not made the mistake. Overall, the most common error arose in the integration of $\cos(\pi t)$. Many thought this integrated to $\pi \sin(\pi t)$ and there were the inevitable sign errors as well. A few candidates did not make their method clear, by writing $F = 4 + \cos(\pi t)$ without preceding it with $F = ma$. If their subsequent mental arithmetic led them to $a = 8 + 2\cos(\pi t)$ this was not a problem, but a slip which then produced $a = 2 + \frac{1}{2}\cos(\pi t)$ or any other incorrect expression caused a serious loss of marks. Fortunately only a few attempts at this question involved the use of the constant acceleration equations.

Question 2

This was a relatively routine SHM question and was answered well by the majority of candidates with many completely correct solutions seen. It was rare to see a script where the first two marks of part (a) were not earned. Most candidates realised that as the particle was at the centre of the oscillation when $t = 0$ they should use $x = a\sin\omega t$ rather than $x = a\cos\omega t$. Use of the latter equation led to loss of accuracy marks but method marks were still available. Some candidates did not realise that to find the amplitude they needed to find the value of x when $t = 0.4$ and use this in $v^2 = \omega^2\left(a^2 - x^2\right)$. Almost all those who obtained a value for a (correct or otherwise) were able to gain at least the method mark in part (b).

Question 3

The majority of candidates could complete, or nearly complete, part (a) successfully. The given answer did allow some candidates to correct their arithmetic errors. Those who reduced their 3 volumes to a ratio (8:19:27) before constructing the moments equation produced clearer and more straightforward solutions than those who worked with the original volume formulae. A few candidates remembered their GCSE work on the ratio of volumes of similar solids and stated directly that the ratio of the two hemispheres was 8:27.

Part (b) was done very quickly and easily by the most able candidates but proved difficult for the majority. Many candidates proceeded straight from Q3(a) to Q4. Of those who attempted part (b), there was a fairly even split between those who took moments about the vertical through *O* for the two weights (or mentally cancelled *g* and used masses) and those who found the coordinates of the centre of mass of the composite body. Some of the latter group found only one coordinate and others made an error in their calculations. Some of the former group produced a moments equation with trigonometrical ratios that cancelled. Since this made the given information that $\tan\theta = \frac{4}{5}$ redundant, they should have been alerted to their mistake.

Question 4

This was probably the best answered question on the paper. Most candidates obtained *T* (not always shown explicitly) by resolving in two directions. There were a few who drew a triangle of forces. Good candidates were able to "see" the triangle without working and wrote down immediately that $T = 50$. A few unfortunately thought they were dealing with 40*g* and 30 even though was it clearly stated in the question that the weight was 40 N and not that the mass was 40 kg. The most common mistake was in the arithmetic – $50 = \dfrac{\lambda x}{0.5}$ so $\lambda x = 100$!

Very few forgot to complete their solution by adding 0.5 to their extension to find *OP*.

Question 5

Part (a) was a straightforward application of the principle of conservation of energy and was done well by many candidates, although some needed several attempts before they arrived at the given answer. Those who tried to quote a single potential energy term involving only the general position, without any reference to the starting point, were misled into thinking they had obtained a correct result. Finding the height difference between the general position and

the starting level proved to be much more challenging than it should have been and some candidates were thrown by having to deal with an angle with the horizontal rather than the more usual angle with the vertical.
Obtaining a complete solution to part (b) proved impossible for many candidates. Usually only the maximum value for T was found correctly, by using $\sin\theta = 1$; many thought that the minimum value was 0. Some candidates found the tension at the top of the "circle", even though their calculations showed that v^2 was negative at this point! It was rare to find a candidate who appreciated that the minimum tension would occur when $v = 0$.

Question 6

Almost all candidates achieved full marks in part (a) but a few lost the last mark for using decimals through their working. The given answer was a fraction and once accuracy has been lost through the use of decimals it cannot be regained. Part (b) proved to be much more of a challenge. The majority seemed to be trying to resolve horizontally and vertically as they produced a correct horizontal equation (M1A1) but their second equation was often $R = mg\cos\theta$ (M0A0). Some even used $R = mg$, as they had in part (a). Others produced correct horizontal and vertical equations (M1A1M1A1) but then included $R = mg\cos\theta$ or $R = mg$ to aid elimination of R. This made their solution invalid and no further marks could be gained. A few candidates attempted to resolve parallel and perpendicular to the plane but did not realise that both of these equations needed a component of the acceleration.

Question 7

Most candidates managed to arrive at the required result in part (a), though some unnecessarily split the motion into two parts, considering freefall initially to find the kinetic energy when the string became taut and then proceeding to consider the taut string and others would clearly have failed had not the answer been provided.
Parts (b) and (c) were often difficult to disentangle. Some candidates took an SHM approach from the start of (b); others solved (b) and then resorted to SHM for (c) alone. Either approach was acceptable, but candidates should take note of the instruction on the front of the paper "You should show sufficient working to make your methods clear to the Examiner". The main fault was not when to start considering SHM but not establishing a correct equation to prove that the motion was SHM; no credit is given for making assumptions of this nature. A fully correct solution using SHM was rare, the equations frequently being unsatisfactory due to using x for the distance from the equilibrium point and confusing it with x as defined in the question to be the extension of the string.
For the non-SHM solutions, in part (b) many candidates assumed that the maximum speed occurred when $x = 0$ rather than when $a = 0$. In part (c) most substituted $v = 0$ in the result from part (a). Some did not expect to obtain a quadratic and so stopped working (or ran out of time?). Of those who obtained a solution for their quadratic equation, some would then try incorrectly to use their value for x as the amplitude in SHM instead of using an equation of motion and Hooke's law. Many equations of motion omitted the weight of the particle.

Grade Boundaries

The table below gives the lowest raw marks for the award of the stated uniform marks (UMS).

Module	80	70	60	50	40
6663 Core Mathematics C1	63	54	46	38	30
6664 Core Mathematics C2	54	47	40	33	27
6665 Core Mathematics C3	59	52	45	39	33
6666 Core Mathematics C4	61	53	46	39	32
6667 Further Pure Mathematics FP1	64	56	49	42	35
6674 Further Pure Mathematics FP1 (legacy)	62	54	46	39	32
6675 Further Pure Mathematics FP2 (legacy)	52	46	40	35	30
6676 Further Pure Mathematics FP3 (legacy)	59	52	45	38	32
6677 Mechanics M1	61	53	45	38	31
6678 Mechanics M2	53	46	39	33	27
6679 Mechanics M3	57	51	45	40	35
6683 Statistics S1	65	58	51	45	39
6684 Statistics S2	65	57	50	43	36
6689 Decision Maths D1	67	61	55	49	44

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