Examiners' Report
Principal Examiner Feedback

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General

The paper was accessible to all candidates in the early questions and contained many familiar situations throughout. Candidates still need encouragement to produce fully justified solutions however when they are required to "show that". Most candidates gave final answers in an appropriate form (such as using 2 or 3 SF when g had been used) but it is worth noting that in Q1b it is not acceptable to leave a fraction in a denominator.

Report to individual question

Question 1

This question provided a very straightforward start to the paper with very few candidates failing to score and many achieving full marks. Candidates showed they knew the formulas to use in both parts and in part (a) the given result was easily justified. The only error seen was the lack of a negative sign after integration but this was rare. Part (b) was usually fully completed but it was very common for many to leave the answer with $\frac{a-1}{a}$ in the denominator, which is not an acceptable form for the final mark to be awarded. There were a small number of poor attempts where candidates did not know how to integrate $\frac{1}{x}$, used the incorrect integral or did not know $ln1 = 0$.

Question 2

This question was accessible to the majority of candidates although in part (a) many candidates struggled to use the correct symbols as defined in the question, leading to issues justifying the given result. Not using x as the distance from the earth's surface was common with these candidates simply replacing x by $x + R$ at the end to achieve the printed result. Some did not make clear use of $F = mg$ when $x = 0$. A few candidates started with $F = \frac{GMm}{d^2}$ often successfully arriving at the correct result. There were many fully correct answers to part (b) and the vast majority all either used the correct starting point with use of $v\frac{dv}{dx}$ and separating the variables or using change in kinetic energy is equal to the integral of the force. A common error was the lack of a negative sign in the force which loses 3 out of the 7 marks. Fully correct work was evenly split between the definite and indefinite integration options but a significant number of candidates used the incorrect values for x often using $v = U$ when $x = 2R$ rather than R, and $x = R$ rather than 0. Some candidates ignored part (a) and defined the distance from the centre of the earth as the variable, often successfully.

Question 3

This question was well answered with the approach required for horizontal circular motion being clearly understood. There were occasional problems with the trigonometry but generally two correct equations were produced and correctly processed. Errors were mostly seen in finding ω or confusing weight and mass. It was again frustrating to see clearly strong candidates lose one of the final A marks by not remembering that when $g = 9.8$ is used their answers must be to 2 or 3 S.F. Part (b) was not answered well. The best explanations came from candidates who used $ml\omega^2$ for the sum of the tensions because it was then obvious that if the length of the arm increased, so did the sum of the tensions. Some said that the radius increased but then considered the change in $\sin\theta$ and could not produce a convincing argument. Candidates were asked for the effect on the sum of the tensions so needed a statement about the sum, not about individual tensions.

Question 4

Candidates were familiar with the approach required for this type of question and many gained full marks in part (a). However even strong candidates showed a poor knowledge of geometry in part (b) with many failing to identify the required angle even when they had the angles needed to find it. The majority of candidates found the centre of mass using the large cone and subtracting the two smaller cones but some did it in two parts, finding the centre with just the top cone removed and then removing the second. There were various errors either due to wrong distances or processing errors. Candidates who used volumes throughout rather than simplifying to find the mass ratio tended to make the processing errors. A few candidates recognised the simplest method of solution was that together the two cones removed had a centre of mass at 4a, leading to a very easy calculation.

Part (b) proved to be challenging and candidates would have benefitted from a large diagram in order to identify the required angle and the angles needed to find it. However, candidates who did not find the correct final angle often managed to gain the first three marks for having enough angles needed to find it. Occasionally candidates used a cosine rule method although often not successfully.

Question 5

This question was generally well answered and candidates were well prepared for parts (b) and (c). In part (a) almost all could set up a correct equation with extension using Hooke's law. The majority of candidates resolved vertically with two tensions containing extensions x and $4a - x$ already in the equation although some chose to set up equations using the length of BC or AC as the variable. This was then solved to find $x = 2a$ but it was quite common for candidates to then fail to show that the other extension would also be $2a$ losing the final mark. Other candidates set up two simultaneous equations in the two extensions and went on to solve these correctly. Some candidates lost marks as they did not show working towards the given answers, simply writing them down after their equations. A few candidates assumed that the extension was the same in both strings from the outset, which was only awarded 1 out of 5 marks. A handful of poor responses were seen where the weight of P was not included. Many candidates seemed to be well versed in setting up the SHM equation in part (b) and many correct equations were seen. There was the occasional sign error but very few errors in the two extensions were seen. Too many candidates still used "a" for the acceleration rather than $\ddot{x}$ and consequently scored 2 of the 4 marks. A number of poor attempts were seen which ignored the weight of the particle. A few others did not include a variable tension or attempted to justify SHM using energy.

Part (c) was often well answered with or without having correctly completed part (b). Almost all employed the equation $v^2 = w^2(a^2 - x^2)$ but occasionally candidates used an incorrect amplitude, usually $2a$ or $4a$ and an incorrect value of x along with that. It is worth noting that this is a method error and not an accuracy error and lost 3 marks out of the 4. Some attempts at conservation of energy were seen, but these were usually unsuccessful due to missing EPE terms. A small number attempted to use $x = acoswt$ then $v = -awsinwt$ but these were usually not fully correct. Frustratingly some errors correctly placing the final square root were seen too.

Question 6

This contained two "show that" questions and it should be emphasized that the expectation of a fully justified, clearly communicated solution is greater in these questions.

In part (a) there were many completely correct solutions using the standard condition

$T > 0$ at the top for complete circles. The energy equation was almost always used correctly and thankfully examples of candidates trying to use a SUVAT equation were very rare. Most used energy and tension at the top but a small number worked from a general position. Some implied that $T = 0$ and calculated the minimum velocity at this point without mentioning the tension and compared the minimum velocity with the actual velocity at the top. Candidates must be encouraged to make a clear statement at the end of their solution.

Part (b) showed more consistency in approach as tension was mentioned in the question. An energy equation combined with N2L at the bottom was most frequently seen but again full marks required a clear conclusion to be made. There was occasional confusion with velocities in the energy equation with some using the original velocity together with the change in GPE from top to bottom. There were also some who used the same equation towards the centre in this part as they had in part (a) even though the direction of mg had changed. Candidates who worked to a general position in part (a) were often able to complete part (b) by substitution of the correct angle.

Question 7

This was generally provided a good opportunity to achieve some marks but full marks were not gained by most candidates. Part (a) required an energy equation. Almost all candidates stated the speed following the impulse *I,* although a handful of candidates went directly to $E = \frac{I^2}{2m}$. The majority had no problem using $F = \mu R$ to find the correct value of the friction. The energy equation from O to A saw an even split between working in terms of the distance OA and the extension x with many arriving at the correct answer. With four terms in the energy equation some made sign errors or assumed that the distance travelled was equal to the extension x, rather than $x + 2$ in the work done against friction and increase in GPE. A few candidates made more work for themselves by first using an energy equation to find the speed when the string went slack and then another equation to find the extension from there. The poor responses seen either double counted the GPE term, included an extra EPE term or ignored the EPE term altogether. The latter would mean that there was no quadratic equation to solve so this proved very costly. A handful of poor responses included friction as a force in the energy equation which again was a costly mistake. Of particular note is that the final two method marks in part (a) were for producing a three term quadratic set to zero and the other to solve it. Although many candidates did show their working out a significant number didn't and simply wrote down their answers from the quadratic equation or even sometimes from a partly simplified energy equation. This meant that candidates who did this from an incorrect equation lost one or both of these method marks.

Many candidates understood the forces required to judge part (b) and used Hooke's Law to find the tension at A. Correct answers mostly involved comparing the sum of the tension and weight down the slope with the maximum friction although some went further to evaluate the acceleration. The most common error was to only consider two forces, with usually the weight down the slope being ignored. A few others had the forces going in the wrong direction while a handful of poor responses thought that conservation of energy needed to be used. Of note was that part (b) was left blank by some perhaps indicating that time may have been a factor by in this paper.

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