Examiners' Report

Principal Examiner Feedback

Summer 2022

Pearson Edexcel GCE

AL Further Mathematics (9FM0)

Paper 4C Further Mechanics 2

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The scripts for this paper covered the full range of ability. There were some clear and confident responses, but many where the candidates showed little understanding of the topics covered.

As usual, the better responses were clearly set out and, when appropriate, accompanied by clearly labelled diagrams. Higher achieving candidates could identify what they needed to do to solve a problem,and produced succinct solutions. At the other extreme there were candidates who needed to take more care in reading the questions to make sure that they had used all the information provided, particularly in question 3 where the rods did not all have the same density, and in question 6 where the cone was not uniform.

In calculations the numerical value of g which should be used is 9.8. 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, as in 2(a), 5(a), 7(a), 8(a) and 8(b), candidates need to ensure that they show sufficient detail in their working to warrant being awarded all of the marks available and that they end up with *exactly* what is printed on the question paper with no errors in the working.

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 and correct answers without working may not score all, or indeed, any of the marks available.

If a candidate runs out of space in which to give their answer than they are 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.

Question 1

(a) This was a very accessible introduction to the paper, with the vast majority of students forming two correct moments equations and finding the correct distances. Many candidates worked with a vector equation. Common errors included inconsistent presence of "a" in equations and arithmetic errors.

(b) Nearly all candidates went on to use the given information about the distance to form and solve an equation in k. Again, some solutions were spoiled by processing errors.

Question 2

(a) This was another question that most candidates approached with confidence. They combined an expression for the driving force (obtained from the given rate of working) with a correct equation of motion to obtain the given differential equation. The most common route was to form the equation of motion in terms of a or $\frac{\mathrm{d}v}{\mathrm{d}t}$ and then substitute $v\frac{\mathrm{d}v}{\mathrm{d}x}$, with many showing use of the chain rule to justify this step. The most common error was to use 200 as a force in the equation of motion.

(b) The majority of candidates went on to separate the variables and integrate the differential equation. Most candidates recognised the form of the integral, but there were a few sign errors. There were a small number of candidates who did not recognise that the equation was separable or had the fraction the wrong way up after separating the variables.

Question 3

(a) The vast majority of candidates attempted to take moments about AC to find the position of the centre of mass of the framework. Many achieved a correct expression with only an occasional processing error. A significant minority of candidates scored no marks, either because they used lengths for masses (ignoring the fact that three of the rods were twice the mass per unit length of the others) or because they used mass per unit length (ignoring the lengths of the rods). A few did unnecessary work in finding the vertical position as well as the horizontal position for the centre of mass.

(b) Most candidates attempted a moments equation about F to find the value of the constant, k. Those who were carrying through an incorrect distance from (a) could achieve 2 of the available 3 marks. Some chose to take moments about C with nearly all realising that the centre of mass of the loaded framework had to lie on FD. There were occasional errors in distances or confusion with masses and lengths.

Question 4

(a) Most students found this task very straight forward and many scored full marks. The most common errors were confusion between sine and cosine and basic arithmetic errors in finding the value of $\cos\theta$.

(b) Many candidates found this part equally accessible. However, it was common to see candidates either ignoring the tension in the horizontal portion of the string or assuming that the tensions in the two portions of the string would be different. Careful reading of the question reveals that it is a single piece of string connected to A and B, with the smooth ring threaded on. With greater attention to detail, most of the errors could have been avoided. When students were able to set up a correct equation of motion, the most common mistake was in the basic algebra, often making errors when square rooting and simplifying.

Question 5

(a) Most candidates used the formula for the centre of mass of a sector from the formula booklet successfully, but a few used an angle of $\frac{\pi}{2}$ rather than $\frac{\pi}{4}$. Having found the distance OG, most then used trigonometry to find the distance from OC, whilst a smaller number used Pythagoras.

(b) Most candidates used moments about *FC* although quite a few preferred to work from *AB*. The most common errors were in simplifying the answer, and in finding the area of the sector.

(c) Several candidates did not use the symmetry of the lamina and chose instead to set up a new moments equation to find the vertical position of the centre of mass. This in itself led to errors, and to an answer that often disagreed with the answer to (b). It was noted that candidates who drew a clear diagram were more likely to use the correct distances, to identify the required angle and to reach a correct conclusion.

Question 6

(a) Those candidates who made correct use of the information about the density of the cone and waited until the final step to simplify their answers usually produced concise and accurate solutions. A large number of candidates did not deal with the density correctly. Many of them simply ignored it and set about finding the position of the centre of mass of a uniform cone. In contrast, there were a significant number of candidates deducing the expressions for the relevant integrals from first principles, which was nice to see though it was not a requirement of the question.

(b) Many candidates deduced the correct location of the centre of mass of the toy and were able to form a correct moments equation. The most common error was to confuse distances, with a significant number of candidates continuing to use the distance of the centre of mass of the cone from its vertex when they needed to be using the distance from the centre of the plane face. Some candidates used the volumes of the cone and hemisphere rather than the weight ratio given in the question.

Question 7

(a) Candidates approached this standard task with confidence. They usually gave a correct equation of motion towards *O*. They understood that they needed to form a second equation by using conservation of energy, but there were a large number of errors in the change in GPE, with many candidates using $\frac{2a}{5}\cos\theta$ in place of $\frac{2a}{5}(1-\cos\theta)$. There was a lot of messy cancelling and crossing out as they attempted to reach the given equation, but very few candidates went back to their initial equations to trace the error.

(b) The starting point for most candidates was either $T=0$ or $T>0$, with $\theta=180°$ either stated or implied. The majority of candidates obtained the correct answer. The most common error was to work with an incorrect value of θ.

(c) The majority of candidates used $\theta=90°$ in the given equation to obtain $a=8g$. A significant number of candidates stopped at that point and did not go on to consider the vertical component of the acceleration.

(d) The majority of responses suggested considering the weight of the string or the elasticity of the string,

Question 8

(a) Many candidates adopted a systematic approach by finding the equilibrium position and setting up an equation of motion for the particle when displaced from this position. Although it is a fairly common scenario, some candidates made little real progress and, although most knew an equation of motion was required, they failed either to find the equilibrium extension or to define an appropriate x. Sometimes an equation was left in terms of a (rather than $\ddot{x}$) with the direction of a not defined. Those who reached an equation of the form for SHM did not always state an appropriate conclusion. Virtually all candidates knew and applied the formula for the period.

(b) The most common approach to this task was to find the maximum speed from the given maximum kinetic energy and then use $v = a\omega$ to find the amplitude. Hence the distance AB could readily be deduced. Some candidates attempted the alternative approach of using an energy equation. This approach was more complicated and less successful. The most common errors were in omitting the EPE at the equilibrium position and/or the GPE. Those who had used $g = 9.8$ ms^{-2} rather than 10 ms^{-2} as directed by the question did not achieve the exact answer of $AB = 2$ m and lost the final accuracy mark.

(c) A small number of entirely correct solutions were seen, with clear and systematic working. Candidates needed to recognise that the motion was in two parts, some under SHM and some moving freely under gravity. There was confusion about distances and speeds at the relevant stages of the motion. Some wrote down an SHM equation for the first distance in the form $x = a\cos\omega t$ but then equated it to 0.25 rather than to -0.25. Occasionally the speed when the string went slack was confused with the speed at the equilibrium position, found in (b). Those who had assumed $g = 9.8$ ms^{-2} but otherwise showed correct working throughout were penalised in the final mark only.