Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel GCE
In A Level Further Mathematics (9FM0)
Paper 4C Mechanics 2

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The candidates for this paper achieved the full range of scores available. For many, the more accessible early questions facilitated a confident start. With a large number of given answers, candidates were able to access the later parts of questions even if they had not completed the earlier parts.

Many candidates offered solutions to all of the questions, but there was a significant minority who omitted some topics.

In calculations, the numerical value of g which should be used is 9.8 m s^{-2}. Final answers should then be given to 2 (or 3) significant figures – more accurate answers will be penalised, including fractions.

If there is a given or printed answer to show, as in questions 2(a), 3(a), 3(b), 4(a), 5(a), 7(a), 7(b), 8(a) and 8(b), then candidates need to ensure that they show sufficient detail in their working to warrant being awarded all of the marks available and in the case of a printed answer, that they end up with **exactly** what is printed on the question paper.

As usual, the best solutions comprised clearly set out work, with an explanation of what the candidate was trying to do. A candidate who says what they are trying to do, but makes a slip, is more likely to gain credit for the work than a candidate who does not make it clear what an equation represents. 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 then 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

Almost all of the candidates identified the need to take moments around the coordinate axes and correctly obtained a pair of simultaneous equations, usually expressed in vector form. The vast majority of the errors occurred in trying to solve these equations.

Question 2

(a) Almost all of the candidates started with a correct differential equation in *v* and *t*, although a small minority omitted the mass of the particle. The majority of candidates went on to separate the variables correctly, integrate and use limits to achieve the given answer.

A small number used alternative methods such as the use of an integrating factor to solve the differential equation.

(b) Most candidates started by writing acceleration as $v\frac{\mathrm{d}v}{\mathrm{d}x}$ to achieve a correct differential equation in *v* and *x*. They went on to separate the variables, but $\int \frac{2v}{2+v}\mathrm{d}v$ proved challenging for a significant number of candidates. Those who rewrote the fraction as $\frac{4+2v-4}{2+v}$ or who used the substitution $u=2+v$ usually went on to obtain the correct value of *D*. Those candidates who attempted to use integration by parts were often unable to complete the integration correctly – those who remembered how to complete $\int \ln(2+v)\mathrm{d}v$ usually obtained the correct solution. A small number integrated the formula for the velocity from part(a), which worked well.

A small minority of candidates tried to make inappropriate use of *suvat* equations to answer this question.

Question 3

(a) Most candidates used the correct formula with $\alpha=\frac{\pi}{4}$ and obtained the given result correctly. Some offered no attempt to demonstrate the result, and some used $\alpha=\frac{\pi}{2}$.

(b) The majority of candidates took moments about *OA*, often as part of a vector equation, and obtained the given answer. The most common errors were in finding the lengths of the arcs *AB* and *OC*, with candidates often using an area formula. Although the question talks about pieces of wire and a framework, some candidates worked the question as if it concerned a lamina.

(c) The majority of the candidates recognised the need to take moments about the point A and thus correctly obtained F in terms of W. The most common error in this approach was to assume that the vertical distance of C from A was r, not $2r$. A surprising error from some candidates was to cancel the $\frac{1}{2}$ on one side of the equation and the 2 on the other side.

A significant minority of the candidates took moments about the point O but then forgot to include the moment of the force acting at A and thus scored no marks in this part.

Question 4

(a) This was a relatively straight forward question about motion in a vertical circle. A few candidates had incorrect signs in the equation of motion and then attempted to "fudge" the given result. A minority of candidates attempted to resolve vertically but most of them did not include a component of the acceleration.

(b) The given result in part (a) meant that candidates started with the correct value of $\cos\theta$ when $R = 0$ and, provided they had a correct equation in part (a), they completed the task successfully. A few errors were caused by slips in the algebra.

Question 5

(a) The majority of candidates identified an appropriate integral and obtained the given result correctly. Most used $\int \frac{1}{2}y^2\,\mathrm{d}x$, but a few preferred $\int xy\,\mathrm{d}y$. Only a minority of candidates found the distance from OA rather than from OB. Despite the warning in the question, there were candidates who went directly from stating the integral to writing down the given answer: this scored only one mark. Several candidates spent time checking that the given area of the lamina was correct.

(b) This part of the question used the given result from part (a), so several candidates answered this correctly without completing part (a). Most candidates took moments about O, but some resolved vertically and took moments about a different point. Most errors involved the use of incorrect distances.

Question 6

There were several clear and concise solutions of this question.

Those candidates who chose to resolve parallel and perpendicular to the surface of the cone often forgot the component of the acceleration in one or both of their equations. Some candidates had the force due to the friction acting in the wrong direction – a few who were uncertain of the correct direction tried both options to be certain of which one gave the greater value of ω.

As in question 4, there were candidates who resolved vertically to obtain the incorrect equation $R = mg\cos\theta$.

Those candidates who left the answer as $\sqrt{\frac{19g}{4}}$ did not score the final A mark.

Question 7

(a) A minority of candidates did not appear to know how to use the information about the variable density of the dome. However, the majority processed this correctly. Several candidates who had correct integrals for the mass and for the moments then tried to manipulate their working to reach the given answer because they did not realise that the distance that they had found was the distance from *O* and not the required distance - they needed to subtract *a* to obtain the given answer.

(b) Some candidates did not attempt this part of the question, and others attempted to integrate again unnecessarily. Most used the result from (a) and the correct distance for the centre of mass of the solid cone in a moments equation about the diameter of the common plane surfaces, and obtained the result required. Very few candidates explained the significance of the modulus in their working.

(c) The majority of the candidates identified the correct angle and formed a correct equation in *k*. A minority considered the two options for the modulus term and went on to verify that only one solution was valid.

Question 8

(a) The majority of candidates succeeded in using Hooke's Law to form an equation in one unknown and went on to obtain the given answer correctly.

(b) For many candidates, this was a straightforward application of a standard and familiar method. A minority did not appear to be working about the equilibrium position, their extensions did not add up to 2, and only a few defined the *x* that they used in their equation. Some candidates did not confirm that their equation was indeed for SHM and some claimed SHM for an equation that clearly did not fit the pattern.

Those who used "*e*" for an extension in (a) (rather than "*x*") and subsequently used this in (b) were more likely to succeed, as were those who drew clear diagrams.

(c) The candidates who attempted this part of the question understood what was required. The use of a model using sine or cosine was more popular than dealing with periodic time, although many did not link the correct initial distance with their model.

(d) Solutions based on a sketch of a trigonometric curve were often successful. The most straightforward method was to use $v = a\omega \cos \omega t$ and then multiply the value of t by 4, but this was not very common. Of those candidates who used $v = 2$ and $x = \frac{4}{15}$, not many were successful in combining the times that they found into the correct final answer.

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