Pearson Edexcel

# Examiners’ Report
# Principal Examiner Feedback

## Summer 2024

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 and it was pleasing that the strongest offered complete solutions with clearly set out work and an explanation of the method or technique employed.

In general, candidates who structure their work carefully and explain what they are attempting tend to score more marks, either because the examiner can more clearly identify what their equation represents or because they give themselves a guide on how to proceed.

Nevertheless, this paper proved challenging for many candidates, especially those at the lower grade boundaries, with some of the Pure Mathematics causing difficulty in terms of algebraic manipulation and calculus skills. It appears a significant minority of candidates did not manage their time allocation well and spent rather too long struggling with algebraic work on early questions to their detriment when it came to the end of the paper. While most candidates offered solutions to all questions, there were a minority who omitted some topics.

The multi-stage structure of questions allowed many candidates who were unsuccessful in earlier parts of question to make a restart later, often scoring full marks on the final few parts of questions. However, some candidates persisted in using their incorrect expressions from earlier parts rather than those printed, and this should be discouraged as accuracy marks are then penalised.

Candidates must also realise that when a question has a given answer which they are required to show, their working needs to be accurate and correct. Many candidates lost marks by dropping and then recovering terms from their equations or by failing to give the conclusion **exactly** as printed: this was particularly prevalent in 2(a) but also seen frequently in 1(a), 4(a), 5(a) and 6(a).

**Question 1**

(a) This was generally well attempted with the minority forming a correct initial equation but a significant minority struggled with the integration, either multiplying by 3 (instead of dividing) or by differentiating instead.

(b) Pleasingly the vast majority who attempted this used their constant from the first part with only a small number of candidates attempting some unrelated work.

(c) Although the vast majority made a good start to this part, work with fractions and negative signs caused some difficulties for some. A significant minority of candidates incorrectly claimed without substitution that the initial conditions would give a constant of integration of zero, and this resulted in losing both of the final two marks.

**Question 2**

(a) The vast majority of candidates recognized that they had to take moments and most successfully formed the original equation. A few worked with a dimensionally incorrect equation, missing a factor of “a” from one side and other errors included use of sin30° instead of cos30° in finding lengths. Only a small number of candidates thought the question was about triangular laminas rather than rods. A significant number of candidates who were otherwise correct did not reference the $d$ from the question anywhere in their solution; some others omitted $a$ from the answer. Candidates who failed to form an equation scored no marks in this part.

(b) The majority of candidates knew what to do here and successfully found $F$ in terms of $W$. From the incorrect responses, a significant number used $4a$ instead of $8a$ and many did not subtract from $4a$ cos30°. A small number had complicated, incorrect expressions involving trigonometry on both sides, usually because they were unnecessarily trying to find an angle between a side and the line through the CoM.

**Question 3**

(a) This question was successfully completed by most candidates, although some used rather lengthy methods with duplication of work and unnecessary geometric reasoning. A number formed the first two equations but then could not use the geometry of the situation or assumed an incorrect angle $\theta$ (usually 45°), so scored no more marks. A small number of candidates successfully resolved radially and tangentially, but in general the majority who attempted this approach incorrectly assumed equilibrium in one of these directions. A significant minority of candidates successfully achieved the correct result then went on to find the resultant of $\frac{4}{3}g$ and the gravitational $g$: this was only penalised by the loss of the final mark.

(b) Most candidates were successful in this part and even when not the majority knew the formula for the time period. A small number of unsuccessful candidates made some attempt to compare linear and angular velocities, via the use of $2\pi r$, but got confused in their algebra or used an incorrect radius.

**Question 4**

(a) This question caused problems for many candidates. Most did know which integral was required and scored the first mark but the integration itself was poorly attempted by a large number, with integration by parts attempted by most of these. A few tried a trigonometric substitution, with a small number doing so successfully. Very strong candidates managed the integration "in their heads" or by recognizing the correct form of the integral and differentiating to find the required constant. A number successfully did a substitution $u = 1 - \frac{x^2}{16}$. Some abandoned their algebraic integration and used their calculator function, losing at least three of the five marks. The majority of those who achieved a value for the integral went on to find the correct value for $\bar{x}$, helped by the printed result, but a number of these did not gain full marks. A small number used the wrong limits; a few tried to integrate $xy^2$. A small number made the integration much easier by using $\int \frac{1}{2} x^2 dy$ and candidates should be encouraged to look at both possible ways to integrate.

(b) This part was much better attempted because candidates knew that they had to integrate $\frac{1}{2}y^2$. A few omitted the $\frac{1}{2}$ and scored M0. A few had the limits incorrect. The majority of candidates achieved the correct result.

(c) Most who reached this part achieved the correct answer; some candidates did not get this far. The main errors from those who attempted it were in equating tan$\theta$ to $\frac{\bar{y}}{\bar{x}}$ or to $\frac{4-\bar{y}}{4-\bar{x}}$

**Question 5**

(a) The majority of candidates made good progress and quickly setup equations using the standard SHM results. However, a number confused their equations and had negative values for $\omega^2$ which resulted in an incorrect quadratic and subsequent negative value for a; this was penalised accordingly. A minority of candidates struggled as they had not learnt the standard formulae and it was only a small number who proceeded correctly from first principles.

(b) Most were successful here but a surprising number made arithmetic mistakes (doubling instead of halving when multiplying by 0.5) or forgot to root their $\omega^2$

(c) Many candidates did this efficiently. From those who struggled, a fair number did not provide a complete method and focused only on finding possible times at which the speed was 2 – sometimes by confusingly using both the sine and cosine approach. A surprising number found the critical values 0.12… and 0.14… then subtracted, showing little understanding of the overall motion.

**Question 6**

(a) The majority of candidates knew the required integral and went on to score all three marks. A few neglected the $y^2$ ($=2^2$) and scored no marks. A small number of candidates attempted to do the problem without any understanding of the question, usually without any integration.

(b) Most attempts scored all marks here. The integration was much better understood as was the formula for the distance. A very small number took the distance from the base of the hemisphere and then did a subtraction, but not always correctly.

(c) Weak candidates did not know how to proceed here, although the majority knew that a moments approach was called for. Most of these correctly looked up the centre of mass for a hemisphere. The main errors were incorrectly using the volume of a sphere instead of a hemisphere and not adding the “6” to the distance of the hemisphere from the base. There were a lot of fully correct answers; many of those who lost the last two marks had 3 instead of 2 in the numerator for their $\tan\alpha$ expression.

**Question 7**

(a) The majority of candidates successfully used energy here, although a small number struggled with the gravitational aspect and had sign errors or extra terms and were penalised accordingly.

(b) Surprisingly few used the equation of motion initially and some, mostly unsuccessful, candidates attempted inequalities or left R in their working until a late stage. The majority of successful attempts were as given in the mark scheme, via finding $\cos\theta$ first, but a good number did form an equation in only $W$.

(c) Almost every candidate who used energy was successful here. However, the majority chose to approach this via projectile motion and this resulted in a variety of outcomes. From those who did not achieve the result, errors were often confusion over direction vertically or forgetting to include the horizontal component entirely. Only a small number of the weaker candidates attempted to use *suvat* without resolving.

(d) This part was mostly successfully attempted, including by those who had not succeeded in previous parts. Common errors included failure to use a correct ratio or one too many or few resolutions of velocities.

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