Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel GCE

In A Level Further Mathematics (9FM0)

Paper 3C Mechanics 1

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General

Overall candidates were able to access all seven questions on this paper and time did not appear to be a limiting factor. Candidates were well prepared for the exam with questions 1, 2 and 4 being the most successful on the paper.

Candidates were able to recall and use standard formulae and were familiar with the context given in all questions. Although the presentation was generally good, there was a distinction between the presentation of routine bookwork and those solutions that were unrehearsed. This was evident in 5(a) where candidates produced a confident start with a clear organised method earning the first 5 marks from a routine process. However, the working for the subsequent 3 marks often became chaotic and the handwriting deteriorated as candidates struggled to reach an unfamiliar result.

If there is a printed answer to show, as in 3(a), 5(a), 6(a), 6(b), 6(c), 7(a) and 7(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. It is evident that most now understand this requirement as many candidates re-arranged their final answer to match the printed answer. This paper had an increased number of given answers to support progression through a question. To avoid over-penalising candidates, some parts had a limited number of acceptable equivalent responses. However, centres should continue to advise candidates that the marking expectation remains the same: to present a given answer **exactly** as printed.

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. As an example, some candidates appeared to abandon their response to question 5 and question 6 only for the completed working to be found at the end of question 7.

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.

Question 1

This question provided an accessible start to the paper with the majority of candidates across all grades gaining full marks. In part (a), almost all candidates achieved the first 2 marks for a correct impulse-momentum equation. Although most continued to find the speed, a significant proportion of candidates at all levels failed to calculate the magnitude of their velocity, instead moving directly onto part (b). The vast majority of candidates scored both marks in part (b) with the most common approach using the scalar product. The inverse tan alternative was also popular and well-executed. Where there were errors in part (b), they generally arose from a poor choice of vectors, incorrectly using the impulse vector instead of both velocity vectors.

Question 2

Performing best on the paper, this question proved to be a good source of marks with a good proportion of candidates achieving all available marks. The majority made a confident start in part (a), often substituting $\frac{16000}{v}$ directly into an equilibrium equation and gaining 3 marks in just two lines of working. It was incredibly rare for candidates to use 16 instead of 16000 showing an improvement in the use of kW. Part (b) presented more challenge. Many candidates assumed the equilibrium and did not set up an equation of motion, gaining only 1 mark for finding the new driving force. Two equations of motion were required, and errors made were predictable: using the driving force in the trailer equation, using both resistances in the car equation and sign errors.

Question 3

This question performed second best on the paper with the vast majority of candidates scoring most, if not all, the available marks.

Part (a) was the first 'show that' question in the paper and candidates confidently established equations for the conservation of linear momentum and Newton's Experimental Law. This routine process was well-rehearsed and candidates who made sign errors were able to use the given answer to identify the error and often made a full recovery by returning to their initial equations to follow the correction through. There was other evidence of good exam technique with candidates re-writing their final answer to match the printed answer exactly. On this occasion, alternative equivalent expressions correctly combining $\frac{1}{3}$, u and $(4+10e)$ were also condoned. This level of flexibility should not be an expectation and centres are advised to continue warning candidates that not writing the answer exactly as printed is likely to forfeit a mark. Candidates who were successful in part (a) usually earned the first 2 marks in part (b) for the velocity of P and the rebound speed of Q. However, setting up an inequality for the final 2 marks presented more challenge. The most common successful approach was to assume that P reversed its direction in (a) resulting in comparable velocities. Those who assumed that P maintained its direction of motion after the collision often failed to consider the sign when setting up the inequality and lost the final 2 marks.

Question 4

Although many candidates achieved full marks on this question, the later parts proved to be discriminatory.

Part (a) was accessible to most candidates with high achievers generally earning all available marks. Hooke's Law was used correctly and combined with a vertical equilibrium equation to find the extension and then the required length.

Many candidates appeared to be well-rehearsed applying the work-energy principle and made good progress in (b). It was pleasing to see that solutions were well-organised with terms often listed in a table which made awarding interim marks much easier when a correct answer was not reached. Candidates using a table rarely made sign errors which was a common cause of lost marks. Another common error was using $2a$ in the EPE denominator, which was the natural length, rather than $2(2a)$. Although less frequent, some candidates missed an EPE term or the work term. This mistake was almost exclusively amongst candidates who formed an energy equation straight away rather than listing in a table.

In part (c), many knew that the maximum speed occurred at the equilibrium point. However, only the high achievers realised that there was a new equilibrium point and understood how to use this successfully. Out of those who did set up a new equilibrium equation, a sign error was often made on the resistance term. There were a very small number of attempts using a work-energy equation with differentiation to find the maximum speed. Although it is a longer method, it was impressive to see the application of calculus almost always used fluently and accurately.

Question 5

This was a very successful question with the majority of candidates scoring highly and achieving most of the available marks.

Part (a) was a 'show that' question worth a substantial 8 marks. The given answer enabled many candidates to correct sign errors and get themselves back onto the right track, improving their performance in this part. Most candidates recognised that the velocity component of *S* perpendicular to the line of centres remained unchanged. The equation for the conservation of linear momentum was often correct, although some candidates did not recognise immediately that the direction of motion of the second sphere would be parallel to the line of centres, and instead introduced a third angle. Newton's Experimental Law was usually well-executed and sign errors were rare. However, it was surprising to see that some candidates additionally stated the result $\tan\beta = e\tan\alpha$ in their working. The relationship cannot be used in this scenario. The two subsequent method marks required substitution and algebraic manipulation. Whilst many candidates produced a neat, fluent response, others were chaotic and spread their solution across several pages with working that was very difficult to follow and mark. There were many examples of good exam technique in part (a) with candidates re-writing their final answer to match the printed answer exactly. Unfortunately, some candidates found the algebraic manipulation very cumbersome and after reaching the required result, did not check that it matched the printed answer exactly, earning 7 marks out of the 8 marks available.

Those who abandoned part (a) rarely attempted part (b) despite all the necessary information being available. The most common approach to part (b) was identifying that $\beta = 90^\circ$, although some showed that the velocity component of *S* parallel to the line of centres was zero, which was equally valid. Requiring a sufficient explanation to reach the given conclusion, the final mark was awarded much less often. Many candidates gave no reasoning at all and simply stated 'hence perpendicular' without referring to the second sphere. Another common incorrect response arose when candidates described the motion of *S* as vertical and the motion of the other sphere as horizontal. This was not acceptable since both particles were already described in the question as moving across a horizontal surface.

Question 6

There were four parts to this question with parts (a), (b) and (c) all having given answers. Unfortunately, many candidates abandoned attempts at (d) or left it completely blank.

Part (a) had at least four possible approaches and the presentation from candidates as they attempted to combine different pathways to reach the given answer was often poor. To make any progress, candidates needed to recognise that the angle between the final velocity and the slope was also α. Those who introduced a new angle rarely progressed to the given answer. The most common correct response was the main scheme followed by the vector alternative 3 approach. Some candidates took longer to reach the answer by introducing e but the intermediary result, $\tan\alpha = e^2$, gave them an advantage in part (d).

Part (b) was very well answered as candidates often had an expression for $v\cos\alpha$ and $v\sin\alpha$ already and combined them via a diagram or a trigonometric identity to reach the given answer.

The given answer in part (c) could be reached very easily from part (b). The formula for Kinetic Energy was almost always stated correctly and even when the terms had been subtracted the wrong way round, candidates were able to rectify their solution due to the given answer.

Part (d) was not answered well and discriminated between the grades. Candidates who understood the mechanics and also had strong Pure skills continued to perform well in the final part. In contrast, others had relied upon the scaffolding and given answers to guide their solutions and once this was removed were unable to answer part (d) at the same level.

Question 7

This question brought with it the level of challenge expected for the final question on the paper with only high achievers accessing all marks. The requirements of 'show that' and 'hence' were often overlooked by candidates, many of whom will lose marks in parts (a) and (b).

Although candidates generally knew how to answer part (a), it was rare to award all 4 marks. Candidates should be advised when answering a 'show that' question, to state the relevant equations clearly before providing at least one step of working to reach the given answer. It is not sufficient to label equations, write '$(1)\div(2)$' then the given answer. This indicates a method but does not show working. Some candidates did not label their equations, simply writing '$\div$' or even providing no method indicators and just the given answer. It was very common for candidates to write down two expressions rather than two equations, showing only how $e_1\tan\alpha$ could be attained and not $\tan\beta$. Many candidates did not appreciate that the diagram represented a physical snooker table, labelling side lengths as speed components. Although proportional, the magnitudes of the side lengths are not necessarily equivalent to the components of speed. When reaching a given answer, it should be written exactly as printed. In this case, writing the equation with the LHS and RHS reversed was condoned. However, this should not be an expectation and centres should continue to warn candidates about given answers.

Part (b) was a 'hence show that' question requiring the result from part (a) to be used in the solution to part (b). Many candidates did not recognise the importance of 'hence' which often resulted in full marks or no marks being awarded in this part. Frequently, an equation linking α and γ was immediately produced with no involvement of β. Although there were many starting points to earn the first mark, they all required an equation in β and γ. If the second mark was awarded for using the result in part (a) to eliminate β, then the final mark usually followed for reaching the given answer. As in part (a), reversing the LHS and RHS was condoned for the given answer but should not be an expectation. No credit was given for reaching the given result by a route that did not involve β.

Part (c) proved to be very challenging for a large proportion of candidates. Those who made any progress usually acted on the guidance in the question, finding an expression for the angle sum. Triangle properties were used to set up an inequality, but many were unsure how this would lead to the required result. Out of those who attempted part (c), the main scheme approach and the alternative approach were equally popular. However, the alternative method was usually more successful. After stating $90 < \alpha + \gamma < 180$, candidates recognised that the angle was obtuse and therefore $\tan(\alpha + \gamma) < 0$. Confident candidates used the tan addition formula to form a fraction and, recognising that the numerator was positive, they stated that the denominator was negative and the required result followed. Other successful solutions were rare but included an impressive proof by contradiction and a beautiful method using vectors.

Very few candidates made any attempt at part (d), particularly if they had struggled with part (c). Those who did, often discussed the idea of subsequent collisions without any detail. The most insightful candidates, who recognised that α was $(90 - \gamma)$, also realised that the direction of motion would be parallel to the initial direction of motion.

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