Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel International Advanced Level In Mechanics M3 (WME03) Paper 01

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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 indicated by a mean mark well above half marks and modal scores for Q1, 2, 3 and 6 being full marks.
Candidates were able to recall and use standard formulae and were familiar with the context given in most questions. This was particularly evident in question 1 on Centre of Mass and question 2 on Hooke's Law where many weaker candidates were able to earn most of the marks available. In contrast, question 4 was a less familiar context for horizontal circular motion and challenged the mechanical understanding and mathematical communication of high achievers.

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) and 6(a) where standard proofs were produced neatly and carried through with accuracy. In contrast 3(b) and 4(b), which were less familiar and did not have given answers, lacked clarity and fluency.

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 given or printed answer to show, 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.

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 his/her answer than he/she is 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

This question provided a familiar start to the paper with more than half of all candidates, from across the grades, gaining full marks. Most were well-rehearsed using integration to find the centre of mass and integrated powers of x with confidence. Candidates understood the requirements of the calculator warning ensuring that the correct integrated expression was

evident in their working. Although candidates did not need to demonstrate the substitution of limits, the correct limits needed to be seen for the accuracy marks. It was rare for candidates to use the wrong limits but since *x* and *y* values were both visible on Figure 1, some did lose marks for this reason.

To be successful in this question, it was necessary for candidates to recall the formula for finding the y coordinate. Unfortunately, one in five candidates struggled to recall the formula correctly, or found the x coordinate instead, scoring either 0 or 1. Given that the calculus requirements were very straightforward, this will be a disappointing loss of marks for some and emphasises the importance of committing standard formulae to memory.

Question 2

Performing best on the paper, this question proved to be a good source of marks with 70% of all candidates achieving all 6 marks. The majority made a confident start, stating Hooke's Law correctly and rarely confusing sin/cos if finding components. Surprisingly few candidates used the main scheme method, forming two equations and producing the answer in a few lines of working. Instead, they used the alternative approach which required setting up and solving four equations. Although this was usually carried out successfully, it presented weaker candidates with more opportunities for processing errors.

Question 3

Containing the first 'show that' part on the paper, this question performed second best with full marks being the modal score amongst high and low achievers. Part (a) was well understood and most candidates were able to arrive at the correct moments equation. It was common for candidates to retain the full volume expressions in their working rather than reducing these to the much simpler ratio $H : h : H - h$ by cancelling $\frac{1}{3}\pi r^2$ immediately. Some candidates felt it was sufficient to progress straight from the moments equation to the given answer without any evidence of algebraic manipulation, factorisation or cancelling. When answers are given in the paper, candidates must show sufficient working to demonstrate how the given answer is reached. Most candidates appreciate now that their final answer must match the printed answer exactly with evidence of candidates re-writing an equivalent expression in the required form.

In part (a), roughly half took moments about *V* and roughly half took moments about the centre of the base, with the algebra being a little more straightforward in the latter case. On the whole, part (b) was well answered but a significant number made no attempt. Those who took moments about the centre of mass were far more likely to avoid mistakes than those who combined a moments equation with the vertical equilibrium equation. The most common error in all methods was to give the final ratio upside down.

Question 4

This question on horizontal circular motion presented the first major challenge on the paper with one fifth of all candidates achieving full marks and one quarter earning no marks at all.

In part (a), candidates were required to show that $\tan\alpha = \frac{1}{4}$ and despite many recognising the mechanical content, they did not show their method with sufficient clarity to earn full marks. Candidates should be advised to state the relevant equations clearly before showing at least one step of working to reach a given answer. It was quite common for candidates to write down expressions, rather than equations, before stating the given answer. Likewise, poor notation caused issues with candidates using *F* to represent friction, centripetal force and *ma* and then stating the given answer. A common misconception that the car was in equilibrium perpendicular to the plane was evident from the frequent incorrect response $R = mg\cos\alpha$.
Successful candidates usually produced a horizontal equation of motion and vertical equilibrium equation as stated in the main mark scheme before combining to reach the given answer. Although far less common, some used the alternative, producing an equation of motion along the plane, using circular acceleration in component form and reaching the given answer succinctly.

In part (b), the inclusion of friction caused major difficulties for candidates and it was common for 1 or 0 marks to be awarded. To make any progress, candidates needed to recognise that the normal reaction was not the same as in part (a). Unfortunately using the same *R* expression in both parts was common. In part (b), responses often showed just an equation of motion with $mg\cos\alpha$ incorrectly substituted straightaway. To earn method marks for establishing a valid equation, all the required terms must be present and any terms that need resolving should be resolved. Candidates should be advised that it is good exam technique to set up the basic equations before any substitution for Friction or *R* and, particularly at this level, to consider whether a new *R* is required for a new part to a question.

Question 5

The modal score on this variable acceleration question was 9 marks out of 12. Parts (a) and (b) were well-answered by candidates of all levels demonstrating a confident understanding of variable acceleration. In part (a), most candidates followed the main mark scheme to reach the given answer. Occasionally candidates made Energy attempts but these were rarely successful, forgetting to use calculus for the work done. There was evidence of good exam technique with candidates re-writing their final answer to match the printed answer exactly. In other cases, candidates who had not considered the minus sign initially, often made a full recovery by returning to their very first line and followed the correction through.

In part (b), the most common error was to leave the answer as $\frac{8R}{5}$ instead of subtracting the radius of the earth, *R*. For some, this was because they did not check that they had answered the question being asked. For others, this was because they had not identified that measurements were taken from the centre of the earth since the context was less familiar. Many candidates made no attempt at part (c) and those who did were often unsuccessful. This part, worth 3 marks, asked candidates to explain their reasoning. This implies that two marks are for sufficient reasoning followed by a final mark for the correct expression. Whilst many gave $\sqrt{2gR}$ as the minimum, they lacked the mathematical reasoning to justify their statement. To make any progress candidates needed to deal with the term $\frac{2gR^2}{x}$. Most successful candidates did so by considering the effect as *x* tended to infinity but a sufficient explanation was challenging even for the high achievers.

Question 6

The first two parts of this vertical circle question were answered very well by candidates of all grades with given answers often written exactly as printed on the paper.

In part (a), the vast majority set up the required equations correctly and proceeded to the given result. Some candidates set up the relevant equations and then simply wrote down the given answer without any substitution or algebraic manipulation. It is advisable to show at least one step of working before reaching an answer that has been given in the paper. Errors were very rare in the energy equation and where there were errors in the equation of motion, they generally came from a missing weight term. In part (b), most candidates found the value for $\sin\theta$ and substituted correctly with any errors arising from the subsequent algebraic manipulation.

The final part distinguished between the grades and whilst higher attainers often gained all available marks, many candidates at lower grades abandoned it completely.

It was equally popular to use the energy approach and the projectile motion approach. Unfortunately, some found the correct vertical displacement $\frac{18a}{125}$ but forgot to add on $\frac{4a}{5}$ to reach the required height.

Some candidates using energy, assumed that all kinetic energy had been transferred to gravitational potential energy, forgetting that the particle maintains the horizontal component of speed at the maximum height. Others using projectile motion either forgot to use the vertical component of the initial speed or they lost marks due to sin/cos confusion.

In these questions, a large clear diagram of the position and direction of flight of the particle would help. However, diagrams were rare and those that did exist were often small and sketchy.

Question 7

This question on Simple Harmonic Motion brought with it the level of challenge expected for the final question. Although the modal score was zero, just over 80% of all candidates were able to gain some marks. The question was structured so that given answers were available to support completion of subsequent parts. However, many candidates who struggled with part (a) made no attempt at parts (b) or (c). Candidates should be advised to attempt the part that follows a given answer because it is not necessarily more difficult. There were also several blank responses that indicated a lack of confidence with SHM rather than the issue of running out of time.

Part (a) required the use of Hooke's Law which was usually written correctly for 2 marks. However, many failed to recognise that an energy equation was required to complete the part and chose instead to write down incorrect working followed by the given answer.

Part (b) awarded 6 marks for proving SHM and for reaching a given expression for the period. This was standard bookwork and well-prepared candidates were often able to achieve 5 out of the 6 marks available in this part. In many cases candidates treated the SHM equation as an intermediate step in reaching the period. Despite arranging their equation of motion to the correct form, $\ddot{x} = -\omega^2 x$, they did not recognise the need to conclude '$\therefore$ SHM' as part of their proof and so lost a mark.

For those candidates who attempted part (c), the vast majority followed the method in the main scheme and achieved all four marks in just a few lines of neat working. It was rare to see the use of $x = a\sin\omega t$ or other approaches carried out successfully. To earn any marks the method must be complete which means that, if followed correctly, it would lead to the required answer. For alternative approaches a complete method usually involves adding to or subtracting from a fraction of the period.

It is often the case that questions on SHM discriminate between the grades and this question was no different.

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