Examiners' Report
Principal Examiner Feedback

January 2023

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

General

Overall candidates were able to access all seven questions on this paper and appeared to be well prepared for the exam. The modal mark for the first six questions was full marks in each case. Time did not appear to be a limiting factor although some candidates may have spent too long on question 4(b) and it is not clear whether this impacted their attempt at the final question.

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 6 was a less familiar context for EPE and challenged the mechanical understanding of high achievers.

Two thirds of this paper involved 'show that' questions and there was a distinction between the presentation in standard proofs and those that were unrehearsed. This was evident in question 5 where part (b) involved regular bookwork and solutions were presented neatly and carried through with accuracy. However, part (a), whilst less mathematically challenging, was an unfamiliar geometric proof and many solutions 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.

Report on Individual Questions

Question 1

This question provided a very straightforward start to the paper with candidates at all grades able to access full marks. Most candidates were well-rehearsed using integration to find the centre of mass and went on to integrate correctly. However, both parts to this question were given answers, consisting of an algebraic expression and units. To achieve full marks, the given units were required, and this was rarely seen. Only 40% of candidates gained full marks and the same again scored 7 out of 8. Missing units is the likely cause of one lost mark as candidates were not penalised twice within this question. As mentioned above, centres should remind candidates that given answers should be stated exactly as printed.

Question 2

Performing best on the paper, this question was a good source of marks with three quarters of all candidates achieving all 6 marks. The vast majority made a confident start resolving in at least one, and usually both, directions. Hooke's Law was usually stated correctly and only a small number confused sin/cos when finding components. Despite establishing a correct method and using substitution correctly, there were still a few candidates who made algebraic slips before reaching the final answer.

Question 3

Whilst high achieving candidates were able to earn full marks in this question on centre of mass, it provided the first major challenge of the paper. The question had a familiar format and candidates recognised the requirements to combine mass ratios to locate the combined centre of mass in (a). Unfortunately, many candidates stumbled when finding the surface area of the conical shell. The formula πrl was given in the question with the vertical height stated and evident on the diagram. However, many candidates did not realise that Pythagoras was required to find l and therefore could not reach the given answer. Many attempts to (a) were abandoned or the given answer simply written to conclude incorrect working.

Having struggled with (a), some candidates did not attempt part (b). However, it was possible to continue with the question since the required information was given in (a). Candidates should be advised to try all parts of a question, particularly following a given answer, as subsequent parts do not always get progressively harder.

Question 4

The mechanical content of this question on variable acceleration was accessible to most candidates. However, the calculus and algebraic manipulation in (b) distinguished between candidates, with lower grades earning half marks and top grades earning full marks.

In part (a) the majority used $v\frac{\mathrm{d}v}{\mathrm{d}x}$ in preference to $\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{2}v^2\right)$ to find an expression for the acceleration. The most common conceptual error in (a) was to simply differentiate v with respect to x but these attempts could still earn a single method mark for equating their answer to 243. Occasionally candidates included $x = 4$ in their solution and so forfeited the final mark.

Part (b) required integration and algebraic manipulation to reach the given answer. It was common to see processing errors here as candidates with weak Pure skills made one or more slips that they could not identify nor correct. Those who integrated successfully often completed the solution but frequently this was after lengthy and unnecessarily complex working. The majority separated and integrated the $\frac{\mathrm{d}x}{\mathrm{d}t}$ equation but failed to realise how close they were to the answer when they arrived at $(2x+1)^{-\frac{1}{2}} = 1-t$. It was common for this to be rearranged to give an expression for x which was differentiated using the quotient rule to find v. Although a longer method than required, high achieving candidates were able to complete this with surprisingly few errors generated.

Question 5
Whilst high achieving candidates were able to earn full marks in this question on horizontal circular motion, it provided significant challenge for those at lower grades who were often only successful in part (b).

The first two marks in this question required simple geometric reasoning but many candidates lacked the clear mathematical communication required to earn both marks. It was common for candidates to refer to angles as θ or α with no indication as to where these were. The written presentation in part (a) was often poor and lacked fluency.

In contrast, part (b) was answered very well. Prepared candidates formed the relevant equations and solved them without difficulty. The correct form of acceleration was used and there were rarely sin/cos errors with components. In this part, the answer was given, which often assists candidates to rectify errors in working. However, there was little evidence that this was necessary as most candidates produced fully correct solutions on their first attempt. Unfortunately for some, they did not state their answer exactly as the printed answer and therefore lost the final mark.

The final part to this question also included a given answer which provided a challenge once again for weaker candidates. Many unsuccessful attempts assumed that the solutions to $T_A = 0$ and $T_B = 0$ would be sufficient to justify the given inequality. Candidates should be advised to state the appropriate condition as an inequality at the beginning of their working. In this case stating and using $T_A > 0$ and $T_B > 0$ was required to earn both method marks in (c).

Question 6
This question on vertical circular motion was one of the most challenging on the paper and, unlike recent years, included an elastic string. Although a quarter of candidates achieved full marks, a fifth of candidates earned no marks at all.

Some candidates with rehearsed processes failed to recognise this as an Elastic Potential Energy question and so made little progress in part (a). Candidates at lower grades often attempted to use Hooke's Law and Tension but realised that they could not reach the given answer and so abandoned the question. In general, those who attempted Conservation of Energy produced an equation that encompassed both EPE terms in addition to GPE and KE and completed this part successfully to reach the given answer.

Part (b) provided further challenge and many who had successful attempts at (a) made no attempt here. Candidates were required to form an equation of motion horizontally at *B* but some incorrectly formed an equilibrium equation instead. Two marks were available for using Hooke's Law at *B* and for some candidates, these were the only marks achieved in (b).

Question 7
This question on simple harmonic motion brought the level of challenge expected for the last question on the paper. It was the only question on the paper with a modal score of zero with one in five candidates scoring no marks at all. Even high achievers struggled to complete this question successfully with some indication that too much time may have been spent by some candidates on earlier working, perhaps question 4.

Part (a) awarded six marks for proving SHM and for reaching a given expression for the period. This involved two elastic strings which is not an uncommon set-up, but candidates do find more challenging. In many cases candidates treated the SHM equation as in intermediate step in reaching the period. Despite arranging their equation of motion in the correct form, $\ddot{x} = -\omega^2 x$, they did not recognise the need to conclude '$\therefore$ SHM' as part of their proof.

Those who had not been successful in (a) were still able to earn marks in (b) and (c) as the SHM formulae appear to be well known by candidates. They were able to use the given answer from (a) to work out ω and proceed to find the speed and the maximum acceleration. Whilst candidates knew that speed should be positive, occasionally the mark in (c) was lost as the maximum acceleration was stated as a negative value.

For those candidates who understood what to do in part (d), they followed the method in the main scheme, using $x = a\cos\omega t$, and achieved all five marks in just a few lines of neat working. A popular alternative used $v^2 = \omega^2\left(a^2 - x^2\right)$ which usually gained all five marks as well. Some candidates chose to use $x = a\sin\omega t$, a valid approach that was rarely carried through successfully. In this approach, candidates were required to solve to find a value for *t* and then subtract from $\frac{1}{4}$ period to find the required the time.

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