Pearson
Edexcel

Examiners' Report
Principal Examiner Feedback

Summer 2024

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

WME03 Examiners’ Report June 2024

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 able to recall and use standard formulae and were familiar with the context given in most questions. This was evident in question 1 on Hooke’s Law and in question 2 on horizontal circular motion, where many weak candidates were able to earn most of the marks available.

The final question presented an appropriate level of challenge and high achievers were able to demonstrate their mechanical understanding and mathematical communication. However, candidates should be reminded to read the question carefully, as many did not follow the directions given in 7(b) which resulted in a loss of marks, even amongst high achievers.

Although the presentation was generally good, there were many occasions where handwriting and letters were difficult to read. Candidates should always take care forming u and v but examiners also reported cases where it was difficult to distinguish between π, x and t. Candidates are advised to present solutions vertically down the page, using all the space available, and to avoid using arrows to direct examiners around their solution.

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

Performing best on the paper, this question proved to be a good source of marks for candidates at all levels. The majority made a confident start in (a), stating Hooke's Law correctly and using vertical equilibrium. Those who confused sine and cosine when taking components were usually able to rectify it quickly due to the given answer. Part (b) was equally successful with most candidates forming an equation for horizontal equilibrium and giving the correct value for *k*.

Question 2

The format for this question on horizontal circular motion was familiar to candidates who performed highly across the grades, most achieving full marks. It was common for candidates to label the angle with the downward vertical and produce solutions similar to the main mark scheme. The most common reason for lost marks in this question stemmed from an incorrect expression for the radius of circular motion with candidates incorrectly using $a,\ d$ or $\sqrt{a^2+d^2}$

In part (a) the vast majority formed a correct equilibrium equation as given on the mark scheme and successfully replaced the sin/cos ratio. It was very rare for candidates to write the incorrect resolution, $R = mg\cos\theta$.

In part (b) most candidates formed an equation of motion with the appropriate form of acceleration and proceeded to eliminate *R* and sin/cos to form an equation in *v*, *g*, *a* and *d* as required. There were several candidates who produced very pleasing solutions, using $\sin\theta = \frac{r}{a}$ to generate an expression for r^2 and avoiding use of the square root, $\sqrt{a^2-d^2}$.

Question 3

Generally candidates were able to achieve most or all of the available marks in this question, demonstrating a confident understanding of variable acceleration across the grades. Candidates found the integration straightforward in both parts and it was rare for the constant of integration to be forgotten.

Unfortunately many candidates, even at the top end, lost marks due to the presentation of their proof in (a). When attempting to reach a given answer, candidates should be advised to show explicitly the initial equation which, in this case, is a differential equation in *v* and *x*.

From the equation $v\frac{\mathrm{d}v}{\mathrm{d}x} = \frac{3\sqrt{x+1}}{4}$, candidates are able to separate the variables and therefore show how to reach the given answer. Candidates who did not produce a full proof, would often start from an intermediary step such as $\int a\ \mathrm{d}x = \int v\ \mathrm{d}v$ or $\frac{1}{2}v^2 = \int \frac{3\sqrt{x+1}}{4}\mathrm{d}x$.

Part (b) was less routine and candidates were more likely to produce the required differential equation as they processed the information in the question. To be successful in this part, candidates needed to form a differential equation in x and t or in v and t with the former being the most common approach. A common error was to start from $v = \frac{\mathrm{d}x}{\mathrm{d}t}$ and proceed to $\int v \, \mathrm{d}t = \int \mathrm{d}x$ with the inevitable confusion that followed from attempting to work with three variables.

Whilst many were able to re-write $4(x+1)^{\frac{1}{4}}$ as $4v^{\frac{1}{3}}$ with ease, others required substantial working to reach the same result. A fairly common approach was to make x the subject of the integrated equation and then differentiate it to find v which was reliable but time-consuming.

Question 4

This question presented candidates with the first major challenge of the paper and whilst there were many excellent solutions, scores of 0 were not unusual. Candidates were directed to use SHM formulae and those who transferred the information from the question to a good, clear diagram were usually able to identify the amplitude as 3 and recognised the need to double $\frac{19}{3}$ for the period. Many without a diagram stated the amplitude as 6 or 4 and also worked with an incorrect period and therefore an incorrect ω.

There were two popular and equally successful approaches to find the speed in (a). The first using $v = a\omega \sin(\omega t)$ and the slightly longer process using $x = -a\cos(\omega t)$ to find x, and then $v^2 = \omega^2(a^2 - x^2)$. Occasionally candidates ignored the mention of SHM and attempted speed = distance $\div$ time before abandoning the question.

Part (b) provided further challenge with many struggling to understand how to use the depth of 8.5 m. Those who produced a clear diagram confidently formed the equation $1.5 = \pm\cos(\omega t)$ or $1.5 = \pm\sin(\omega t)$ any of which could lead to the required answer. To complete the question it was necessary to consider the context and whether their t value was the time after low-tide, high-tide or the midpoint. For those who reached a t value, they almost always converted it correctly to a time. This was particularly impressive for several candidates who had chosen to convert to seconds in part (a) and continued in seconds throughout the question.

Question 5

Candidates are typically well-rehearsed using integration to find the centre of mass as required in part (a) of this question. However, in this case candidates were expected to produce the relevant straight-line equation for themselves, either $y = \frac{1}{4}x$ or $y = r - \frac{1}{4}x$.

Weaker candidates appeared to struggle, choosing instead to leave a blank response and move onto the more familiar part (b). Surprisingly many candidates ignored the given volume of *C* and chose to use integration here as well. Candidates should be advised that in an exam, the phrase '*You may assume that …*' permits use of the equation or formula without proof.

Part (b) was well understood and most organised the mass ratios and distances in a table before arriving at the correct moments equation. Distances were almost always taken from the vertex as required and those who used the plane face quickly realised that they needed to subtract their expression from 4*r* to reach the given answer. When answers are given in the paper, candidates are advised to show at least one line of working to demonstrate how the given answer is reached. Most candidates know now that their final answer must match the printed answer *exactly* with evidence of candidates re-writing an equivalent expression to match the required form.

Those who were successful in part (b), and who produced a diagram for the point of toppling, recognised which lengths to use when finding an expression for $\tan\alpha$ in part (c). Without a diagram, candidates were more likely to use incorrect lengths or to form the reciprocal.

Question 6

This question on vertical circles challenged the understanding of mechanics of many candidates. Although the vast majority established the correct energy equation to start part (a), many weaker candidates were unable to progress further, earning only the first three marks in this question. Those who recognised the need to form an equation of motion towards the centre were also able to eliminate *v* and rearrange to make $\cos\theta$ the subject. Candidates who used *R* in their equation of motion, usually substituted *R* = 0 and successfully reached the given answer, writing it in the exact form required.

Good candidates were quick to evaluate $\cos\theta$ and to find an expression for the velocity at *B*, recognising that the vertical circle question had developed into a projectile problem in part (b). Those who failed to resolve the velocity at *B* rarely achieved any further marks in the question despite there being a viable energy approach. A common error in part (b) was using the speed at *A* as the initial speed of the projectile motion. This mistake often occurred amongst chaotic working, implying that the candidate was struggling to visualise the mechanical context whilst also processing the algebra. It is good exam practice to annotate a Figure when one is provided in the question, as it is usually in place to support understanding.

The strong candidates who successfully found the velocity components at *C* almost always found $\tan\alpha$ correctly, rarely giving the reciprocal.

Question 7

This question on Simple Harmonic Motion brought with it the level of challenge expected for the final question on the paper. Most candidates made a good start to part (a), recognising that the given answer came from an energy equation. However, when proving a given answer, candidates should be advised to state clearly the initial equation followed by at least one line of working before reaching the given answer and stating it *exactly* as printed. If there is not sufficient working then candidates are at risk of losing marks.

When using the formula for EPE, particularly in a 'show that' question, it is recommended to show the full substitution. When candidates begin the process with a simplified expression, it is very difficult for examiners to determine a valid method if mistakes are made.

Many well-prepared candidates progressed quickly through part (b) without taking the time to read the instructions which clearly directed them to prove SHM by 'differentiating this equation with respect to x'. No marks were available to those who used an equation of motion. Those who differentiated with respect to x, usually recognised the need to find an expression for $v\frac{\mathrm{d}v}{\mathrm{d}x}$ before re-writing in the form $\ddot{x} = -\omega^2 x$ and concluding '$\therefore$ SHM'.

Part (c) challenged candidates at all levels and many made no attempt. Without understanding how to find the amplitude, no further progress could be made. Those who used $U = a\omega$ often went on to do very well in this part. After establishing the amplitude, candidates were usually able to find a partial time but many stopped at this point.

The most efficient, but rarely seen, approach was to use $x = a\sin(\omega t)$ and recognise that the angle $\frac{5\pi}{6}$ led directly to the required time. It was far more common for candidates to use $\frac{\pi}{6}$ or $x = a\cos(\omega t)$ and, whilst knowing that an extra step was required, they struggled to complete it successfully.

Despite the level of challenge in this question, it was pleasing to see many well-presented and efficient solutions.