Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

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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 able to recall and use standard formulae and were familiar with the context and format of most questions.

Results from standard bookwork such as in questions 4(a) and 5(a) were pleasing with many weak candidates earning most or all of the marks available. However, even high achievers struggled with question 2 and whilst the mechanical concepts were very straightforward, it was evident that the context was not well-rehearsed.

Although the presentation was generally good, there were many occasions where solutions were difficult to read. Examiners identified cases where expressions within brackets were very small, very squashed or had been crossed through and over-written making the first attempt indistinguishable from the second attempt. When a candidate is checking over their solution, they should ensure that the flow of work is logical with clearly formed letters and neat crossing out. They should carefully consider whether their answer is in the required form and that they have identified keywords, answering the question in full. A candidate's response to question 6 was a good indicator of exam technique.

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

Providing an accessible start to the paper, 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 recognised the calculator warning in the question and clearly showed the differentiation and integration required to access any marks.

In part (a) candidates chose the correct expression to differentiate, processing the powers of t with accuracy and substituting $t = 8$ to find the acceleration.

Although there were many fully correct solutions to part (b), using the continuity of v at $t = 4$ to find the value of k did not occur readily to all. Whilst many found k later in their working, others made no attempt and gave their final answer in terms of k. Definite integration was generally more successful than indefinite integration as many using the latter either overlooked the need for the constant of integration or incorrectly used $x = 0$ when $t = 0$.

Question 2

Candidates are usually very successful solving problems involving Hooke's Law and equilibrium. However, despite the supportive diagram, this question provided a surprising level of challenge across the grades and scores of 0, 1 and 2 were not unusual.

The most common and very costly error was to ignore the extension in the horizontal section of the string, scoring a maximum of half marks. Other responses demonstrated a misunderstanding in the natural length of the string portions, assuming that $3a$ could always be used. Others assumed that tension was constant throughout the string.

There were many fully correct responses where candidates failed to use symmetry to observe that the extension in PX was equal to the extension in QY. Instead they found three tensions and extensions before combining to obtain the correct answer.

The most successful approach was to recognise symmetry and therefore study only the forces at one point, usually P. Stating correct horizontal and vertical equilibrium equations along with Hooke's Law gave the first 5 marks. Solving the correctly formed equations to find two extensions gave the next 3 marks. Candidates who reached this point successfully usually achieved full marks, applying very simple trigonometry to complete the question.

Question 3

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, finding the extension in *OB* by applying Pythagoras or observing the 3,4,5 triangle, then subtracting the natural length. Most candidates could recall the formula for EPE and used this at least once to earn a method mark. The final three marks were only available for an energy equation with all required terms: GPE, 2 KE, 2 EPE. Those who formed this equation correctly usually earned all the available marks, with sign errors being very rare.

It was more common amongst weaker candidates for an energy term to be forgotten, either an EPE term or the GPE, scoring a maximum of 3 out of 7. Candidates should be encouraged to check that all energy terms are included when their energy equation is formed; those who established an energy table with initial and final energy values rarely made mistakes.

Question 4

Candidates at all levels are well-rehearsed using integration to find the centre of mass and most were successful in part (a). Many confidently used the correct formula for $\bar{y}$ processing both numerator and denominator simultaneously. It was pleasing to see many accurate solutions presented with fluency, using correct notation and limits throughout.

In contrast the geometry required to answer part (b) brought a surprising level of challenge. It was common for candidates to score only 1 mark in part (b) for identifying $\bar{x}$ and whilst this could be identified using symmetry, many chose to use integration again to find the distance from first principles.

Without finding the perpendicular distance of the centre of mass from *O*, no further marks were available. The first approach in the mark scheme was the most successful in finding the required distance and, once established, most formed the moments equation correctly and progressed to achieve all marks. Those with neatly labelled diagrams were more likely to be successful processing lengths and angles with accuracy. Responses with chaotic working and messy labelling often produced nothing of value and candidates should be reminded to make their methods clear, even if a question is abandoned, to support examiners in reading their work.

Question 5

The proof required in part (a) was standard bookwork, providing an accessible start to this vertical circle question and with all 4 marks being earned by almost all candidates. Whilst most used conservation of energy as expected, others did not appear confident, instead using the conservation of energy first to a point level with the peg and then to the required point. The result was usually established successfully but, without a clear method, the use of U, v and V with two energy equations often appeared confusing to examiners who found the formation of letters difficult to distinguish between.

Although a familiar question, forming the equation of motion required in part (b) distinguished weaker candidates from the majority. The correct form of circular acceleration was used with the correct radius but many forgot the weight component, stating $T = m\frac{v^2}{r}$. All required forces must be present, and resolved where appropriate, to earn the method marks for an equation of motion. Candidates at this level are expected to collect like terms, even if this requires expanding a bracket first, but many stopped abruptly after making T the subject instead of simplifying the $mg\sin\theta$ terms. It was rare to see sign errors or confusion between $\sin\theta$ and $\cos\theta$.

Most earned all available marks in part (c) regardless of their success in earlier parts of the question. As usual the most common error in this familiar context is using $V = 0$ rather than $T = 0$ at the instant when the string becomes slack. This reveals the misconception that the particle stops in midair at this instant, treating the motion of the particle as vertical and ignoring the horizontal component of velocity.

Question 6

The opening to this question on horizontal circular motion required a proof for the length *OP*. Candidates by now understand that when an answer is given in the paper, their result must be written *exactly* as printed. There were very few occasions of $1.5a$ being stated and the final A mark being lost.

It was common for candidates at most levels to label the angle with the downward vertical as θ and produce solutions similar to the main mark scheme.

The most common reason for lost marks in part (a) stemmed from the processing of the trig ratio. Those choosing to use $\tan\theta$ did not have an expression involving *OP* or $(a+x)$ which often led to chaotic working, with possible relevant expressions scattered across the page and then a bold statement of the given answer, $OP = \frac{3}{2}a$. Candidates must recognise that a 'show that' question is a form of mathematical proof and to obtain all available marks a proof requires a flow of connected true statements leading to the required result.

In part (b) the vast majority formed a correct vertical equilibrium equation and successfully replaced *T* and $\cos\theta$ to find a value for *R*. Possibly due to the phrasing in the question, others obtained the correct answer through a series of statements rather than explicitly using an equation: first finding *T* then $T\cos\theta$ before writing $mg - \frac{1}{2}mg = \frac{1}{2}mg$.

Responses to part (c) usually included a correct expression for EPE but a common error was to use $\frac{1}{2}m\omega^2$ for KE, failing to convert from angular speed to *v*. This led to the dimensionally incorrect expression for KE of $\frac{mg}{2a}$ instead of *mga*. Although most candidates recognised the need to find an expression for KE and an expression for EPE, several did not identify the phrase 'sum of' in the question and did not attempt to add the expressions together.

Question 7

This question on Simple Harmonic Motion brought with it the level of challenge expected for the final question on the paper. Many well-prepared candidates progressed quickly through part (a) reaching the required result and earning all available marks. Strong candidates understand that the result must be written in the form $\ddot{x} = -\omega^2 x$, using $\ddot{x}$ for acceleration and conclude '$\therefore$ SHM' to achieve all marks.

There were many correct solutions from candidates who were less confident and had used the space around their diagram to check the order of their terms and the expected cancelling. It was pleasing to see that their efforts revising, combined with good exam technique, led to a well-presented solution in the main body of the page.

Unfortunately scores of 0 were also common in part (a) when candidates did not form an equation of motion for a general position and used a fixed value for tension. Low scores were also seen when candidates formed an equation of motion with the correct weight, $\frac{3mg}{2}$, but an incorrect mass, using $m\ddot{x}$ instead of $\frac{3m}{2}\ddot{x}$. Some noticed their error when they obtained an incorrect period and attempted to go back through their working to squeeze the $\frac{3}{2}$ into position. Although there were occasional sign errors, most knew the standard result and went back through their working to change appropriate signs. Candidates must be careful when correcting their work and over-writing should be discouraged. They must ensure they have returned all the way back to the first line and that the solution can be read by an examiner. A $\frac{3}{2}$ can be inserted into position far more successfully than attempting to turn a plus sign into a minus sign by simply thickening the line in the middle. To obtain full marks in a proof involving SHM, the working must be fully correct, use correct notation and conclude.

Many candidates who struggled with part (a) made no attempt at part (b). However, those who made an attempt usually scored the first 2 marks with ease for identifying the amplitude as $\frac{l}{2}$, recalling a relevant SHM equation and making the substitution to produce any of: $x = \pm\frac{l}{2}\cos\omega t$, $x = \pm\frac{l}{2}\sin\omega t$, $\ddot{x} = \pm\frac{l}{2}\cos\omega t$, $\ddot{x} = \pm\frac{l}{2}\sin\omega t$.

One approach led directly to the required time, $\frac{1}{\omega}\cos^{-1}\left(-\frac{1}{2}\right)$, but it was common for candidates to forget the minus sign or prefer a sin form, both of which required additional work with the period to obtain the final two marks.

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

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