Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

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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 appeared to be well-prepared for the exam, frequently able to recall and use standard formulae and were familiar with the context given in most questions. This was particularly evident in question 2 on elasticity and question 4 on horizontal circular motion where many weaker candidates were able to earn most or all of the marks available. In contrast, the SHM in question 6 and the projectile motion in question 7 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 2(a), 6(a) and 7(a) where standard proofs were produced neatly and carried through with accuracy. In contrast, 5(a) and 7(c) were unstructured and many solutions lacked clarity and fluency.

Many of the most successful candidates produced neat diagrams to support their understanding and identify key features in the toughest parts to a question. This was most notable in 6(d) and 7(c). There appeared to be many good candidates who may have achieved at a higher level in these questions if they had taken the time to draw a diagram.

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

There was a very good response to the opening question on this paper. Part (a) required candidates to 'show that' a given answer followed from the information in the question. The majority correctly formed an equation of motion using $v\frac{\mathrm{d}v}{\mathrm{d}x}$ for acceleration and were able to reach the given answer in just a few lines of working. Occasionally candidates identified a sign-error in their solution and were able to successfully follow through a correction from their first line of working to reach the given answer. Unfortunately, some candidates did not recognise the 'show that' requirement and lost a mark by starting their proof with $\frac{1}{2}v^2 = ...$ In order to gain full marks, candidates were expected to form a differential equation in v and x and separate the variables to reach the given answer.

Part (b) was also very successful with most candidates using the information and the given answer in (a) to find the constant of integration and then the required expression. It was rare for candidates to form definite integrals but when done so, they were equally successful.

Question 2

This question provided a familiar context for an elastic spring and was the most successful question on the paper. In part (a) candidates were guided to use the principle of conservation of mechanical energy to reach a given answer. The vast majority were able to form a correct energy equation with all the given terms and it was rare to see any confusion using $\cos\theta$ instead of $\sin\theta$ in the GPE term. Candidates should be advised that it is good exam technique to provide at least one line of working or simplification between establishing an energy equation and reaching a given answer.

To answer part (b) candidates needed to establish an equation of motion and use Hooke's Law to replace tension. In most cases acceleration was found correctly and candidates received all marks. It was very rare for candidates to replace g with 9.81ms^{-2}. However, it is worth highlighting to candidates that this value is not accepted on mechanics papers. When substituted before reaching a correct expression for acceleration in terms of g, candidates lost the final mark.

Question 3

Candidates made a confident start to part (a), setting up the integral $\int xy^2\,\mathrm{d}x$, expanding correctly and integrating powers of x successfully. Surprisingly some candidates also used integration to find the volume of S. Since this information was given in the question, the working was unnecessary.

The correct limits were usually shown and although the substitution of limits did not need to be seen, candidates were expected to evaluate the integral before dividing by the volume (or mass) to reach the given answer. Some candidates hoped to achieve all 5 marks by simply substituting the curve equation into the formula and then writing down the answer that was given in the question. Although it is possible to perform this calculation in one step on a calculator, candidates should be advised to show their integration and to evaluate integrals, particularly in a 'show that' question.

Part (b) presented the first real challenge on the paper with many candidates struggling to form the relevant triangle. Those who labelled $\frac{31}{24}$ on the given figure were usually able to identify the required lengths and therefore complete the question successfully.

Question 4

Candidates were well-prepared for this routine question on horizontal circular motion and labelled forces correctly on the given diagram. It was rare to see friction acting the wrong way or sin/cos confusion but these errors would cost at least 3 of the 9 available marks.

Most recognised the 3,4,5 triangle from the distances given in the question with candidates usually defining θ as the angle between the vertical and the incline. Solutions were often well presented with six marks being earned quite quickly from two correct equations. It was most popular to produce horizontal and vertical equations but many who chose to form equations of motion parallel and perpendicular to the incline were also successful. Amongst all candidates, the correct form for acceleration was almost always used.

Some candidates formed horizontal and vertical equations successfully but then used $\mu mg\cos\theta$ for friction. This revealed a misconception amongst weaker candidates and was a common cause of lost marks.

Question 5

In general candidates found it difficult to achieve all available marks in this question. In part (a) candidates were required to use algebraic integration to find the centre of mass of a semicircular lamina. Most used the circle equation $x^2 + y^2 = r^2$ with either of the approaches on the main mark scheme. Although some attempted to use parametric or polar form, it was very rare to for them to see any success. Surprisingly, some candidates also used integration to find the area of a semi-circle, despite the area of a circle being given in the question. Several solutions were poorly presented in part (a) hinting at uncertainty.

In contrast, candidates appeared to be more comfortable with the familiarity of part (b), often presenting mass ratios and relevant distances in a neat table. Some candidates chose to present the information using column vectors. In this proof question, method marks were awarded when the relevant moments equation was formed. This required information to be taken out of a table and it also required the relevant information to be taken out of the column vectors. In part (b) the distance was defined as *d* in the question and so the final mark was only awarded when candidates reached the given answer, stating $d = \frac{4a}{\pi}$.

Those candidates who were successful in (b) usually gained full marks in part (c). However, candidates should be reminded to read the question carefully to avoid losing unnecessary marks. In part (c) some marks were lost for finding the angle θ but missing the step to find $\tan\theta$ and others used the distance from *B* rather than the distance from *A*.

Question 6

This SHM question involved a particle connected to two vertical elastic strings and provided significant challenge for many as the question progressed.

Most reached the given answer in part (a) successfully using the main method in the mark scheme. The required distance in the question was defined as *AE* and the final mark was awarded only when the candidate stated the given answer *exactly* as printed in the question.

Part (b) proved to be a challenge for candidates with many neglecting to include the weight of the particle in their equation of motion. Although many attempts appeared to reach the given answer, no marks could be earned unless all the relevant forces were included. It was pleasing to see that in almost all cases the correct form of acceleration was used throughout the solution and many candidates chose to conclude '$\therefore SHM$'.

To continue the question, candidates needed to use the correct amplitude. This caused many to stumble and lose the remaining available marks. Successful candidates were unsurprised by the question and produced a simple diagram that helped them to identify the amplitude correctly.

In general, those who were successful in part (c) quoted and used $v^2 = \omega^2(a^2 - x^2)$. Others were just as successful using $x = a\cos\omega t$ and differentiating. Although an energy approach was very rare, it was usually carried out correctly. This was very impressive given that the energy equation required 5 terms, 3 types of energy and several different distances.

Part (d) was often left blank and was completed successfully only by a minority of those who attempted it. Nearly all attempts used a correct distance formula with either sin or cos and $\pm\frac{l}{8}$ but struggled to make the necessary adjustment to find the required time. The best responses often included a simple diagram or sin/cos sketch to support an accurate understanding of the problem.

Question 7

Candidates recognised the familiar style of parts (a) and (b) in this vertical circle question with many scoring all available marks or 6 out of the 7. The given result in (a) was obtained quite quickly by equating energy at two points or using ‘gain = loss’. Those who made sign errors or wrote *u* and *v* on the wrong side of the equation were able to correct their solution successfully by returning to their first line of working and making the necessary amendments. The given inequality in (b) was frequently obtained by starting with the inequality $\frac{mv^2}{r} \ldots mg\cos\theta$, substituting for v^2 and rearranging. However, the last mark in (b) was only available to those who made reference to the normal reaction *R*. The inequality is only true because of the condition that $R \ldots 0$. The best attempts to ‘show’ the result, gaining all marks in (b), began with an equation of motion, stated $R \ldots 0$ and then used (a) to rearrange correctly. It was common amongst poor attempts at (b) to see the statement $v \ldots 0$. Whilst true, it is not a valid condition to base the result upon.

Examiners were impressed with the vast array of creative approaches used by candidates in part (c). Most candidates recognised the move into a projectile motion problem and tackled it by exploring vertical and horizontal motion. Whilst there were at least seven different approaches, the most common and successful was the main scheme approach, finding the time vertically to reach the level *BC*, working out the horizontal distance travelled in this time and comparing it with the distance *BC*. Unfortunately, some lost marks for using $BC = 2r$ instead of $BC = 2r\sin\theta$. The second most common approach found the time required to travel the horizontal distance *BC* and identified that the vertical displacement was negative at this time. In all cases a conclusion was required stating that the ball had fallen back into the bowl.

The presentation for part (c) was generally quite poor, lacking structure and organisation. Expressions and equations often appeared on the page leaving examiners to work out where they had come from, what they represented and whether they had been abandoned or used elsewhere in the solution. This was particularly challenging for examiners as candidates also switched between rationalised expressions, simplified surds and *g* replaced with 9.8 in different parts of the problem.

The most successful candidates provided a simple diagram of the projectile motion and indicated when they were working horizontally and vertically. They usually referred to a relevant *suvat* equation and also carried the same expression for *v* or *t* throughout their working. It was rare but delightful to see some beautifully constructed solutions from able candidates who had reached the final part of the paper and appeared to enjoy the opportunity to display their secure understanding of the problem.

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