Pearson Edexcel

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Principal Examiner Feedback

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General

The paper proved to be very accessible with the majority of candidates able to make good attempts at all six questions. Generally, time was not a factor but there were a few who did not attempt the last question, possibly because they didn't know where to start. The first three questions provided the opportunity for candidates to settle into the paper and score some easy marks. There were some excellent scripts but there were also some where the standard of presentation left a lot to be desired. This, in some cases, made it difficult for examiners to follow the working. Candidates should try to spread their work out as this will make it easier to read.
Question 1 was the best answered question, with the vast majority of candidates scoring all three marks.
The worst answered question was question 6, where just under a third of the candidates were unable to make any progress but almost an identical number were able to score all of the marks.
Questions 4, 5 and 6 produced a similar pattern of responses, with a small proportion unable to make much progress but large numbers scoring all or almost all of the marks.
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.
There were a number of printed answers to show on this paper (e.g. 3(b), 5(a) and 6(a)), and candidates *must* ensure that they show sufficient detail in their working to warrant being awarded all of the marks available and that they end up with ***exactly*** what is printed on the question paper, with no errors in the working. It is evident that many understand these requirements, clearly establishing necessary equations, including at least one line of working and re-arranging their final answer, when necessary, to match the printed answer. However, there were a number of cases where it was similar but not *exactly* as printed. Candidates run the risk of losing a mark in such cases.

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 proved to be a very friendly starter.
(a) The vast majority of candidates were able to score the mark, with answers of 0.5g or 4.9 being the most common. The most common error was to omit the g whilst a few used g = 9.81 or gave a fractional answer, both of which were penalised once for the whole question. A few, seeing the word ‘magnitude’, squared and/or square rooted their answer.
(b) Most candidates found the value of the limiting friction by multiplying their answer for (a) by $\frac{2}{7}$ which earned the M mark and then realised that X had to be the same value. A significant number lost the A mark after having found the correct value of F for not stating a value for X, as the question required.

Question 2

This question was accessible to all candidates, particularly parts (a) and (b).
(a) This was generally answered very well either using a *suvat* equation or by finding the gradient of the first section of the graph. Some lost the second mark for writing incorrect units or, occasionally, omitting the units altogether (m s^{-1} being the most common error with the units). A few candidates confused acceleration with distance and found the area under the graph during the first six seconds.
(b) The vast majority scored all three marks here. The most popular approach was to sum the separate areas of the triangle and the rectangle or alternatively to find the area of the trapezium. Occasionally the ‘ $\frac{1}{2}$ ’ was missing from either the area of the triangle or the trapezium. This error scored no marks for use of an incorrect formula. Those who used *suvat* methods tended to be less successful than those using an area approach.
(c) This part was more challenging. Most candidates recognised that they needed to subtract their answer to (b) from 200 to get the distance travelled from t = 18 to t = 24. Whilst some used $s=\frac{1}{2}(u+v)t$, the most common successful approaches were to find an expression for the sum of the area of the triangle and rectangle or the area of the trapezium and equate that to 40. However, a significant number of candidates used the area of a triangle rather than a trapezium and wrote $\frac{1}{2}(10-U)\times 6=40$ leading to $U=-\frac{10}{3}$ then ignored the sign and wrote it as a positive answer which coincidentally was the correct answer but they scored no marks for an incorrect method. A small number of students attempted to find U by using *suvat* methods for the whole race, usually without success.

Question 3

A very well answered question with many candidates using a clearly labelled force diagram and gaining full marks for (a) and (b). It is always good exam technique to annotate the diagram to support the answer.
(a) Most candidates were able to resolve perpendicular to the plane to obtain $R=mg\cos\alpha$ and then replace $\cos\alpha$ to obtain the required answer. A few multiplied by sin instead of cos but this still earned the M mark. However, those who used tan or divided by sin or cos lost both marks. A few responses chose to use a decimal approximation for the angle which could score both marks in this part.

(b) This was a "show that" question, so full and accurate working was required. The vast majority wrote down an equation of motion parallel to the plane, $mg\sin\alpha - F = ma$ and then used their answer from (a) to replace *F*, cancelled the *m*'s and factorised to obtain the given answer. Note that when there is a printed answer to show, candidates must give their answer in ***exactly the same form*** to guarantee earning all the marks. Common errors were setting $mg\sin\alpha = F$, using an incorrect trigonometrical ratio, missing *m*'s or *g*'s, using $\mu = \frac{5}{12}$.

(c) This was worth one mark, so the answer needed to be clear e.g. the particle does not move, it remains at rest. Some candidates went on to try to justify their answer, but this was not required. A considerable number said it would slide down more slowly, or more worryingly, it would slide up the slope. Stating only that the acceleration was zero or that the forces were in equilibrium did not score the mark, as the particle could still be travelling at constant speed. However, stating that the acceleration was zero or that the forces were in equilibrium *and* that the particle remained at rest did earn the mark.

Question 4

(a) This part of the question was worth three marks and required candidates to produce a rigorous proof to show that $c = 3$, either by using trigonometry or an isosceles triangle or both. It seemed that many candidates were telling themselves that the answer was obvious but were uncertain as to how to go about justifying the fact. Most candidates struggled to produce a rigorous proof, instead just stating, *without justification*, that for a bearing of 135^{o}, the distance travelled in the *x*-direction would have the same magnitude as the distance travelled in the negative *y*-direction or equivalent. They were able to score two of the three marks available if they then went on the show that $c = 3$. Those candidates who drew a diagram and labelled it with all the information from the question were generally more successful in scoring all three marks than those who either did not draw a diagram or whose diagram did not include some of the information given. Some candidates correctly used $\tan 135^{o} = \frac{-6}{2c}$ or the equivalent, without a diagram. Common errors included not being able to correctly sketch a bearing of 135^{o}, or omissions of angles or sides in the diagram. The negative sign caused issues in several instances and was sometimes glossed over. There was also some poor algebra. A few candidates incorrectly wrote $2c + 6 = 0$ to obtain $c = 3$.

(b) The majority of candidates realised the need to differentiate the given expression for **r**, with $c = 3$ substituted, to obtain the velocity, and most of these differentiated correctly. They then substituted $t = 4$ and used Pythagoras to find the speed, giving their answer either as an exact value or an appropriate decimal equivalent. A minority correctly found the velocity but then stopped and lost two marks. A few candidates delayed substituting $c = 3$ until the end and a few delayed putting $t = 4$ which made the working a lot more demanding. About half worked with column vectors instead of using **i** - **j** form. Common errors included calculation slips when evaluating the speed or when substituting $t = 4$, misreading the expression such as losing the negative sign in the **j**-component and losing the **i** and **j** and not recovering to use components. A few candidates tried to use a *suvat* approach not realising that this was not a constant acceleration situation.

(c) Many of those who differentiated in (b), successfully differentiated their velocity vector to obtain the acceleration vector. However, a significant number of candidates did not know how to proceed from there and the second stage of the process proved to be a discriminator. It was only the stronger candidates who realised that their acceleration vector had to be a multiple of the given vector. Those who did make this link generally were able to complete the question successfully. A number of unsuccessful candidates just set the **i**-component of the acceleration equal to -1 (or more rarely to -27). Most of those who compared **a** to $k(-\mathbf{i}-27\mathbf{j})$ were able to reach an equation in *t* only which they then tried to solve. Fewer candidates used a ratio approach but a significant minority of these used the reciprocal of the correct ratio but were still able to score the method mark. Having reached a correct equation in *t* or *T* only, some then struggled to obtain the correct answer. There were a few candidates who tried to use a *suvat* approach for this part not realising that this was not a constant acceleration situation and scored nothing.

Question 5

(a)This part required the derivation of an equation for the flight path of a stone moving freely under gravity given the initial speed and angle of projection. There were many excellent responses seen where candidates used horizontal and vertical components of the initial velocity in $s = ut + \frac{1}{2}at^2$ to find expressions for *x* and *y* in terms of *t*, with the majority realising that the acceleration was zero in the horizontal direction. Occasionally the velocities were not resolved or the acceleration in both directions was taken as *g*, but such instances were rare. Most proceeded to eliminate *t* correctly and obtain the printed equation. Since it was a given answer any slips in working tended to be rectified including any previous cos/sin confusion. The final mark did require 9.8 for the value of *g* to be seen being used explicitly in the working. Although full marks were often achieved in this part of the question, there were candidates who failed to make any valid progress, often because they equated their vertical distance to zero, possibly proceeding to calculate *t* and then realising they had no strategy for finding a general equation. Those who quoted the general equation for a trajectory and substituted in the given angle achieved no credit, but this was only very rarely seen. Some omitted this part of the question entirely, but it did not preclude them from accessing all marks in the subsequent parts.
An alternative but significantly less common approach was to quote the general equation of a parabola as $y = ax^2 + bx + c$ and use the coordinates of three specific points to find the constants. Most realised that $c = 0$ and achieved the first two marks. Generally, the points corresponding to the range and the greatest height were found using *suvat* equations, although other points were possible. Some attempted to use completing the square with the maximum point at (60, 22.5) but failed to deal properly with the coefficients. Occasionally the derivative at $x = 0$ was used successfully to find the value of *b*. There were a fair number of entirely correct solutions seen using this method but also some which lacked organisation and a clear strategy.
(b) Most candidates scored the two available marks in this part for finding the range *OA*. The most common method was to set $y = 0$ in the given equation and solve to find *x*. Sometimes a two-step *suvat* approach was adopted, generally successfully. Those who made no progress in part (a) often achieved the marks here.
(c) This part was generally done well with many correct answers seen. Often a *suvat* approach was used to find *H*, the greatest height. Alternatively, many used the symmetry of the parabola and substituted $x = 60$ (half the range) into the given equation to find *y*. Some differentiated to find the maximum (or used a calculator) but occasionally gave 60

(the x value) rather than 22.5 (the y value) as their final answer. Completing the square was also employed successfully on occasion.

(d) In this part the majority of candidates recognised that H would be greater than K i.e the particle would reach a greater height in a model without air resistance than it would in a model including air resistance. Not all, however, gave a satisfactory reason with some just claiming 'because of air resistance' or 'air resistance limits the maximum height reached' rather than explaining that air resistance opposes the motion of the particle or causes it to reduce its velocity more quickly. A few referred to the initial velocity being less which was incorrect since the speed of projection was given and was not part of the model.

(e) There were many correct answers for possible limitations of the refined model in this part. The most popular included not accounting for spin, wind effects, dimensions of the stone and the inaccuracy of using $g = 9.8 \text{ m s}^{-2}$. Continuing to model the stone as a particle was an acceptable limitation, but those who thought that this meant mass was ignored did not gain the mark. Also, the ground not being entirely flat and horizontal was not credited since it was not part of the model. Only one limitation was required, and extra incorrect answers were penalised to avoid rewarding those who made a list of possible answers hoping that at least one might be correct. However, the instances of this happening appeared to be fewer than in previous years.

Question 6

The most successful candidates in this question tended to indicate what they were doing at each stage – taking moments about A, resolving horizontally, etc, in words or symbols. It is always good exam technique to annotate the diagram to support the answer. The majority of errors affecting performance in the question as a whole were due to incorrect force diagrams: the normal reaction force at C was sometimes drawn vertically upwards rather than perpendicular to the rod, and an extra reaction force was occasionally put in at G and/or B. Most candidates worked with the angle theta, but a few did convert into terms such as $\sin\left(90^\circ - \theta\right)$ and used these successfully.

(a) There were a good number of fully correct responses to this 'Show that' question. The majority of candidates found and used the trig ratios successfully, possibly because the answer was given in the question, which allowed them to identify whether they had calculated or used the wrong one. If a candidate gained one or two marks, but not all three, it was usually due to sin/cos confusion or making arithmetic errors when rearranging the equation. Some candidates lost all the marks because they omitted the a's and so did not have a moments equation, but most included these initially and then cancelled appropriately. The final mark was occasionally lost because explicit use of $\cos\theta = \frac{3}{5}$ was not seen or the candidate chose to give the force another name (such as R_C) and so did not arrive at the printed answer. A common error was using $2a$ instead of $1.5a$ as the distance. A few candidates gave the impression of having arrived at the required answer, but on closer inspection were not correct in their work. The most common example of incorrect working was $S = 0.5Mg\sin\theta = \frac{2}{5}Mg$. Some tried to formulate a proof based on the given answer that did not involve taking moments, but instead tried to resolve forces, and received no credit. Most candidates presented their answer in the given form, although S on the RHS was occasionally seen.

(b) Many candidates scored all six marks in this part. Resolving vertically and horizontally was the most common and the most successful method. There were few errors apart from sin and cos confusion. Taking moments about C to give an equation in R and F and then resolving was the next most common method, but candidates were more likely to make errors using this approach, either by confusing sin with cos or by omitting a force entirely. Very few candidates resolved parallel and perpendicular to the rod and most of those who used this method failed to arrive at the correct answer due to the more challenging algebra. Occasionally candidates wrote dimensionally inconsistent equations by failing to include lengths in all of their moment terms or, more rarely, erroneously including lengths in their force terms. Errors included missing a g where there should have been one or not having the correct number of terms in a moment or a resolution equation. A surprisingly common error was for students to confuse the reaction force S with the reaction force at A, resulting in the incorrect equation $F = \mu \times \frac{2}{5} Mg$ Some candidates lost method marks by resolving forces that did not need resolving (for example, by writing an equation with both $Mg\sin\theta$ and $S\cos\theta$). Whichever method was used, early substitution for F into their solutions was often seen, with almost all candidates realising that they needed to use $F = \mu R$. Some candidates clearly still incorrectly believe that μ cannot be greater than 1 and were 'dismissive' when their value was. It was not uncommon to see very messy responses, with multiple attempts and work crossed out. Many candidates made a good attempt at solving for μ, but this was often impeded by the lack of clarity over the previous equations. The mark scheme enabled candidates who used a correct method but who made sign errors, confused sin and cos or used incorrect distances to score half marks (generally, M1A0M1A0M1A0), while those with more fundamental misunderstandings were prevented from accessing the dependent method mark; this seemed to sort out the candidates well. When μ was found, most candidates gave the answer as a fraction or to an appropriate degree of accuracy.

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