Moderators' Report/
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Summer 2016

Pearson Edexcel GCE
in Physics (6PH01)
Physics on the Go

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This is the penultimate time that the Edexcel AS level in Physics has been sat by candidates. Section A of the paper contains 10 multiple choice questions while section B contains questions of increasing length and usually of increasing demand. Unit 1, Physics on the Go examines both the mechanics and materials component of the course providing a transition for candidates between GCSE and A2. Although there is no overlap with the other units, the skills and concepts covered, especially in the mechanics topic are used as a basis for the teaching of circular motion, momentum and simple harmonic motion in units 4 and 5.

This paper enabled candidates of all abilities to apply their knowledge to a variety of styles of examination questions. Many candidates showed a good progression from GCSE to AS level, with prior knowledge extended and new concepts taught and understood well. The quality of open response style questions was good, with improved performance at the lower end of abilities. Calculations were carried out, at the lower end of the ability range, as expected with these candidates usually picking up full marks in 2 mark calculations and some of the marks in 3 or 4 mark calculations. Probably explaining the lack of increase in performance at the top end of the ability range, more able candidates did not perform well on the longer calculations, in particularly questions 18bii and 19biii. The preciseness of the answers at the top end of the mark range was also not quite as good as expected and candidates, where they should have been scoring 3 or 4 out of 4 marks often only scored two marks.

As all the candidates sitting this exams are not doing so for the first time, as expected, the mean mark rose on the paper to 46.8 which was 2.5 marks greater than the mean on same paper last June. The spread of marks around the mean was smaller than last year, mostly due to better performance by lower ability candidates. The more able candidates tended to score around the same marks as on previous papers. Timing was not an issue at all with this paper, with the vast majority of candidates, across all abilities, completing all questions on the paper. The mean score for questions 1 to 10 across all candidates was 8.1, about two marks higher than is usually seen on this paper.

Section A – Multiple Choice

	Subject	Percentage of candidates who answered correctly	Most common incorrect response
1	Newton's third law	91	C
2	Properties of materials	93	-
3	Displacement-time graph	48	A
4	Falling objects in a vacuum	71	C
5	ΣF = ma	41	C
6	SI base units	95	-
7	GPE and power	90	D
8	Vector addition using Pythagoras	96	-
9	Components of forces	91	-
10	Work done	92	B and C

Section A, the multiple choice items were answered extremely well with the best candidates typically scoring 9 and candidates of about E grade ability scoring 7 or 8. Only a few of these items provided some discrimination across ability ranges and these are mentioned below.

Question 3

Although the context was familiar, the graph was less so as many candidates will have seen the displacement-time graph for a bouncing ball but not necessarily with just one bounce isolated. The key to remind students in such cases is if the ball is accelerating, it will have an increasing gradient or if decelerating has a decreasing gradient. Hence the difference between correct graph D with an increasing and then decreasing gradient compared to the commonly selected graph A that starts with a decreasing gradient and must be for the upwards motion of an object and not downwards.

Question 4

This question required the candidates to identify that distractors A, B and C were mass dependent while distractor D solely depended on the acceleration of the sphere which in a vacuum would be *g*. With the most common incorrect response as C candidates should be reminded that objects falling freely through a vacuum may have the same acceleration but the resultant force responsible for this acceleration is equal to *ma* and is therefore mass dependent.

Question 5

This was the most challenging of the multiple choice items and was generally only answered correctly by the best candidates. This question applies $\Sigma F = ma$ to an object accelerating through water. Considering the forces acting on the brick, $mg + F = ma$ giving F as $m(a-g)$ which would give a negative value. Some candidates may have reached an answer of $m(g-a)$ which would only give the magnitude of the resistive force and not the direction as the equation used to reach the equation ($mg - F = ma$) includes this force as a negative term. This may have confused the better candidates with the weaker candidates , going by the most common incorrect response of c, just applied $F = ma$ to the numbers given in the question without consideration of the context.

Section B

Question 11

This question was answered well with most candidates identifying that there would be upthrust acting on the ball and for there to be an initial acceleration, this upthrust had to be greater than the weight of the ball. Many good candidates then went on to describe an upwards acceleration or upwards resultant force. Some candidates described the conditions for movement at constant velocity which, although eventually correct, do not explain the initial acceleration as the ball moves from rest when released. Such explanations were treated as neutral as could be true for a later stage of the balls motion.

Question 12

12a: The vast majority of candidates achieved full marks on this item with the odd mark being dropped due to an omitted or incorrect unit or an arithmetic error in the calculation.

12b: Only the top 11 % of candidates answered this question successfully with the majority of answers suggesting that the measurements from the moon should be multiplied by 6. This was not answered as intended and it had been thought that more candidates would appreciate that as the spring balance measures the mass, the scaling factor to be used was to enable the same balance on earth.

12c: Most candidates at E grade ability or better managed to pick up a mark here for describing the use of a stiffer spring or one with a greater Young modulus on earth, but only the best candidates identified that this was to produce the same extension for the greater force on earth. Those who got the idea of producing the same extension stated this quite eloquently.

Question 13

13a: While it was very evident that candidates understood the behaviour of a ductile material under increasing stress, very few could precisely make reference to the points at which changes in behaviour occurred. It was also evident that there was a great deal of ambiguity as to the position of the key points within a material's behaviour at which these changes occur. Elastic behaviour was commonly seen to start at the limit of proportionality. Ductile behaviour was also assumed to start at the elastic limit, even where the candidate had indicated that this was just beyond the linear region of the graph. Where candidates did mark points to make reference to on the given stress-strain graph, there was some tolerance but these points were frequently misplaced and could not be credited. The most common mark to award was the linear section at the beginning but candidates that had not made reference to the graph could not score further. It was thought, on the writing of the question, that candidates would make reference to the shape of the graph i.e. linear, curved and flat, when describing the behaviour but most referred to reference points they had made.

To clarify that ductile behaviour by definition is where, with little or no applied stress or force there is a large strain or extension of the wire. This is only represented by the region of the graph with the lowest gradient i.e. the flat section. While this behaviour is plastic as well, the plastic behaviour of the graph starts at the elastic limit which is not far beyond the end of the linear region (limit of proportionality).

13b: Most candidates referred to the gradient of taking a pair of points and using stress/strain, however, not all remembered to refer to the linear region.

13c: Candidates often over extended the curved region of the graph and while there was some tolerance, this prevented them from scoring the first mark. Brittle materials show little or no plastic deformation so any curved region should have only been small in relation to the total strain that the graph covered. Most candidates managed to get the second mark demonstrating a greater Young modulus with a steeper graph. If the material had a greater Young modulus than the wire then, at all points, it should have a higher gradient. Again, there were limits as to how much the initial section of the graph could overlap with the graph for the ductile wire as too much of a similar gradient did not score.

Question 14

14a: Similar questions have been asked in the past and attempted with a better success rate. To credit the construction of a vector diagram, the minimum was required. The candidate only had to construct a diagram from which measurements could be taken to obtain the magnitude and direction of the resultant force. Labels were not rewarded, only a correct diagram with the resultant drawn in the correct direction. A good number of diagrams were correct although not all had any or a correct direction for the resultant. The accuracy of some diagrams led to measurements being out of range, however, these candidates tended to pick up 1 mark for the diagram. Some candidates chose to calculate the magnitude and direction, often as well as drawing a correct diagram. This would have enabled the candidate to score full marks. Some candidates resolved the 12 N force into components parallel and perpendicular to the 16 N force. This method usually stalled at this point as few managed to combine the parallel forces and construct a scaled right angled triangle to obtain the resultant. A few abandoned the use of a diagram and used Pythagoras to calculate an answer at this point.

14b: (i) was answered correctly by the vast majority of candidates as was (ii). Only a small number of candidates used a force, or more typically an energy, as one of their examples, preventing them from scoring this mark.

Question 15

15a: Very few candidates identified that there would be horizontal forces in the horizontal section of the bridge at A. Therefore, few scored the full 3 marks for the free-body diagram. Some candidates introduced an upwards force at A, assuming there to be a normal contact force which would have acted on the lorry and not on the bridge. While most candidates correctly labelled the weight and the tension in the trusses at A, weaker candidates that had added the upwards reaction force at A were penalised and only scored 1 mark.

15b: The first mark for identifying that the trusses supplied a vertical force was missed by many candidates. However, many candidates, from within their prose, described the purpose of the trusses in that they distributed the weight. Virtually no candidates made reference to the horizontal forces, the key reason for the use of trusses. However some good responses were seen, showing good understanding of knowledge of components of forces to the context. There was a fine line for some between describing the function of multiple trusses compared to a single truss, which was not the question with the purpose of the trusses.

Question 16

16a: While most candidates had a good idea of the concept of viscosity, few could formally describe it in terms of the resistance to flow.

16bi: The most commonly awarded mark was MP2 for a link between the time taken to drain and the viscosity. Few references were made to rate of flow so MP1 was rarely awarded. Reference to rate of flow was required as this concept linked viscosity to the time taken to drain i.e. the physics knowledge behind the concept of the viscosity cup. One reason that this question was not as successfully answered by many candidates as it should have been, was the actual question being asked. It asked why this method could be used. This was interpreted by some candidates as a description of potential results, such as a large viscosity would take longer to drain. Ideally a general relationship between the quantity being measured (time) and the quantity to be determined (viscosity) would have explained sufficiently why this method can be used.

16bii: This was answered well by many, although responses that only described a change in temperature without specifying how the temperature had changed did not score.

16c: A notable number of candidates were not precise enough with their answer, identifying the error but not specifying how the time would be effected by this. Some sensible possible errors were suggested as seen on the mark scheme, but a line had to be drawn between errors that were a fault with the method and those that would be introduced by carelessness. References to temperature were not credited as this would not be a factor that would change during a single use of the cup. The most common incorrect errors were the height of the cup above the floor, the tilting of the cup and movement by the person holding the cup. It may be good to encourage students to discuss why they would not affect the time taken to drain.

Question 17

17ai: This question was answered well with many candidates scoring full marks, even at the lower end of the ability range. Components of the initial velocity were usually correct and used correctly in the relevant equation of motion. Less able candidates did sometimes slip, forgetting to multiply the time calculated, usually using $a = (v-u)/t$, by 2 to find the total time. Some candidates used $s = ut + ½ at^2$ with a displacement of 0 to calculate the time for the whole journey, negating the need to double time. The calculated time was usually used correctly with speed = distance/time with the horizontal component of speed enabling many candidates to score at least 2 marks.

17aii: As candidates had to provide a trajectory that was higher and further for 1 mark, the shape of the path was not penalised as had been on previous papers. Some candidates who lost the mark had drawn their line higher but then brought it down to meet the other line.

17b: Again, similar questions have asked the same on previous papers and there was an improvement in the quality of responses with lower ability candidates. There was effectively just 1 mark available for each force to justify the increase or decrease in the range of the ball and the most significant point was required. Candidates often included correct physics that was accepted in previous exams where more marks had been available, but failed to mention the key points on the mark scheme. There is still the misconception among many candidates that horizontally there is a force propelling the ball, so answers such as 'air resistance reduces the resultant force horizontally' were seen. Other common errors included the omission of 'horizontal' when describing a decreasing velocity. This is also true for part of the vertical motion and answers have to be more specific. MP2 and MP4 for identifying the effect on the range were most frequently awarded with many candidates identifying that the time of flight if there was an upwards force (MP3), would increase.

Question 18a

18ai: Candidates were not penalised for including too much of a decreasing acceleration however those that did not have any at all and constructed a graph consisting of two straight lines, one with increasing velocity followed by constant velocity, only scored the first marking point for an initial acceleration. The graphs should have had a decreasing gradient from the start followed by a horizontal region of constant velocity.

18aii: As was frequently seen on the paper, candidates in the lower half of the ability range did much better than on previous papers in their calculations and particularly with the extended responses. This description was worth 3 marks and many managed to score at least 2 marks here. Usually a mark was dropped as candidates did not explain why the drag would eventually increase to equal the weight i.e. increase due to increasing speed.

18aiii: Few candidates made the comparison between densities or forces, choosing to refer to the size, mass or volume of the drop itself. Answers such as 'the drop is tiny' or 'the upthrust is very small' were common, but as no comparison had been made, could therefore not be credited. It is the relative weight of the rain drop in comparison to the weight of the displaced air that makes the upthrust negligible.

18bi: This was answered correctly by nearly all candidates. Marks lost were due to careless conversions from minutes to seconds.

18bii: This was a difficult calculation requiring candidates to pull together use of Stoke's law, the density equation, weight and volume in order to score any marks. 3 marks are low for such a question and sometimes similar questions have had a different marking structure. In this case, if a candidate could not construct $\rho V g = 6\pi r \eta v$ then really no further marks could be scored. There was poor use of the equation for volume $\frac{4}{3}\pi r^3$ with some candidates even using the terminal velocity for volume in the equation. Those that could construct the equation and make correct calculations sometimes were let down by their re-arranging, usually of the division by a fraction (4/3) and although they scored the first 2 marks, they then failed to score MP3. Another common error was the omission of g when considering the weight and $\rho V = 6\pi r \eta v$ was seen and substituted into, but could not gain any credit as was effectively an incorrect formula.

18c: Answered well by some, particularly by those that had perhaps practiced previous laminar and turbulent flow diagrams. There were still laminar lines stopping abruptly (usually on the lower edge of the raindrop) or crossing too soon (usually due to careless drawing) or changes in direction of laminar lines were deemed to be too sudden i.e. at 90° or greater. It was expected that some transition between the two regions of flow would be shown so turbulent flow that suddenly started with no origins could not be credited.

Question 19

19a: Most candidates were able to calculate a gradient from the given graph scoring the first marking point. Unit errors and power of 10 errors let some candidates down and is a common problem when candidates are asked to use information from a graph. Answers, when calculated, were generally in range although candidates should be warned that precision when reading from a graph is expected to be within half a small square.

19bi: The change in extension of the spring was 0.06 m however most candidates failed to appreciate that the work done to compress a spring by 0.06 m is less than the work done in changing the compression of a spring from 0.03 m to 0.09 m. Candidates, upon realising that a simple calculation of $0.5 \times (2.1 \times 10^3) \times 0.06$ gave a value half of the show that value then usually proceeded to use work done = force x distance. Although this led to the correct value for the work done this was an incorrect method. Such a method would only been accepted had the candidates stated that the force used of 2.1×10^3 N was in fact the average force applied to the spring during the compression. No candidates were seen to write this and therefore this question was not answered well. Few candidates attempted to directly calculate the area under the graph by counting squares or using the area of a series of shapes. If a candidate was successful in scoring one mark, it was usually for use of $E_{el} = ½ F\Delta x$ with an extension of 0.06 m or 0.09 m.

19bii: While many candidates identified that there would be a transfer of energy from elastic potential energy to kinetic energy few considered the energy transfers as the boy rose. Therefore few responses were seen to include references to the gain in gravitational potential energy and fewer responses implied that this came from the initial elastic energy.

19biii: As would be expected there was a definite correlation between those candidates that had identified the transfer to GPE in part bii and those scoring more than 1 mark with this item. While many candidates picked up MP3 for use of the kinetic energy equation, few knew to consider a transfer to GPE and include it in their calculation. Many that did attempt to calculate the GPE just equated it to the kinetic energy without consideration of the initial elastic potential energy.

19c: The physics being examined in this question was similar to questions 11 and 18aii however the context this time was a little more challenging due to the introduction of a third body, the child. To score the first mark the candidates had to clearly identify the third law pair and solely discuss a reaction force in the upwards direction of the ground o the pogo stick. Some candidates dedicated most of their response to describing the interactions between the child and the pogo stick, often correctly but not specifically answering the question. As is usually seen with such questions, many stated Newton's laws without direct application to the context. Marking point 2 was probably awarded the least, with confusion from some candidates as to the origin of the resultant force with many stating that the force of the ground on the pogo stick was the resultant force with no reference to weight at all. While most candidates identified that there would be an acceleration, by this point they had forgotten the requirement to link their explanation to Newton's laws and no mention was made at all of either N1 or N2.

Summary

This paper provided candidates with a wide range of contexts from which their knowledge and understanding of the physics contained within this unit could be tested.

A greater understanding of the context and question being asked would have helped many candidates. A sound knowledge of the subject was evident for many but the responses seen did not reflect this as the specific question was not always answered as intended.

Based on their performance on this paper, some candidates could benefit from more teaching time and extra practice on the following concepts and skills:

- Slow down during the multiple choice items so that key words in the command sentences and distractors are not missed.
- Remember to check responses if there is time at the end of the paper in case careless mistakes have been made, especially for errors in powers of 10, taking data from a graph and missing units.
- Read the question carefully and do not make assumptions of your own so that the actual question asked is being answered.
- Be careful how you use the data you are given in what seems to be the correct formula. Think about what you are calculating e.g. if it is a resultant force then have all the individual forces acting on the body been considered or if it is the work done on the spring, have you considered the correct region under the graph for the extensions produced?
- Learn precise definitions for the properties of materials given in the specification.

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