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Physics PHA6/B6/X

Unit 6: Investigative and practical skills in A2 Physics

Report on the Examination

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GCE Physics, PHA6/B6/X, Investigative and Practical Skills in A2 Physics

General Comments

The question paper for Section A Part 1 contained a printing error for which AQA apologises. Many centres contacted AQA to express concern about the questions in which candidates used solar cells but the evidence seen in the scripts shows that these questions worked as anticipated and the candidates were not disadvantaged. As in 2010 centres had taken note of the PSV exercises and candidates were well briefed to answer the questions, the theme of which was the absorption of energy.

The questions in Section A Part 1 proved to be slightly less accessible than those in 2010 where more credit was given for the acquisition of data. Both papers placed about the same demand on numerical analysis but the 2011 questions gave more credit to extended writing, traditionally an area in which average candidates do less well. These candidates had the benefit of the 2010 paper for practise and the idea that uncertainty is half the range, done badly in Section B in 2010, was much better known in the answers seen to question 1(a)(iii) seen this year. In 1(b) candidates were required to evaluate their data to test if the amplitude of an air-damped pendulum decreased exponentially; a similar type of analysis question appeared in the 2010 paper and most candidates were well prepared, some even keen to demonstrate the criteria they applied to arrive at their decision. The ability to evaluate an experimental procedure was tested in 1(c) and this generated a wide range of responses, mostly inspired by good experimental practice.

Despite the simplicity of the graphical exercise in question 2, candidates were still expected to apply the basic standards and conventions they know will be expected of them in the Section A Part 2. Difficult scales, crudely or inaccurately marked points and thick or hairy lines all cost marks although just as costly were missing units or inconsistent precision in the recording of the raw data or the read-offs from the graph.

The evidence produced in Section A Part 2 should have given candidates an opportunity (in Section B question 1) to discuss how well and to what extent their data illustrated an exponential relationship between the solar cell output voltage and the quantity of ink absorbing the light; that so few did was a major disappointment. But another worry (also mentioned in last year's *Report on the Examination*) is that when the log of a quantity is recorded, the majority continue to treat this data without enough consideration. In this experiment, for the vast majority of candidates, the most significant figure in every result for the ln(V/mV) data was five and so where only two further figures were given (as was nearly always the case) the data effectively reverted to two significant figures. It was common to see the same ln(V/mV) value given for two or more values of Q, particularly where, as in many cases, the gradient began to flatten out, so the graph became stepped. Most candidates forfeited a significant figure mark because of this approach. Candidates must understand that when the place holder does not change, the examiners will not treat it as a significant figure; as a general rule it is best to record logged data that has been evaluated to three decimal places and treat these as a special case of derived data.

Relying mainly on following well established conventions about tabulation and graph drawing the discrimination in this section is always low and even grade E candidates should expect to get 80% of the marks. This year most candidates got the same things right and the same things wrong so discrimination was marginally less than in 2010 when the requirement to draw curving graph and some tricky initial calculations spread the candidates out.

In Section B, question 1 provided candidates with the biggest challenges but discriminated strongly in favour of the candidates who were in the top 20% of the mark range. Compared with those at about the A boundary, these candidates performed better on this question by about the same margin as the A candidates outperformed the candidates at the E boundary. To gain a high mark for this question, candidates not only had to read from their graph with precision but use the largest possible steps in their gradient calculation. When describing the form that a ln(V) against Q graph would take if the situation is analogous to the absorption of ionising radiation by different thicknesses of metal, these candidates express themselves using words rather than relying on algebra and take care to say that the graph would 'be a straight line with a negative gradient'. However, even these candidates often did not included relevant quantitative detail in their answer to 1(b)(ii). While most candidates had produced graphs showing a clear linear trend between Q = 100 and 300 ml, thereafter the gradient decreased and in some cases became positive. Additionally, the initial reading of V_0, which some tabulated and logged to plot on their graph, usually fell well above the trend line. Very few candidates made even a qualitative observation about these features. As mentioned in last year's *Report on the Examination*, the concept of inverse proportion is not understood well; many, in describing the linear trend shown on their graph claimed that $\ln(V)$ was inversely proportional to Q.

The majority who addressed the suggestion that they comment on the quantitative evidence, used their gradient and intercept results together with a randomly chosen value of Q to compute the corresponding $\ln(V)$ value. It did not worry these candidates that their answer nearly always coincided with the read-off from the graph but if they had thought about it carefully, they would have seen this was bound to be the case. Very few saw the need to use the directly measured V_0 result as part of this analysis and correspondingly few could progress beyond five out of seven marks.

Good candidates made quick work of much of the remaining questions; the less able candidates found questions 2 and 4 to be fairly accessible although for them, question 3 proved to be quite challenging. The impression gained is that the best candidates are performing at about the same level as last year while the less able will have found a little more in this paper that they could do compared with 2010.

Section A Part 1

Question 1

Candidates investigated the decrease in amplitude of an air damped pendulum and analyse their data to see if the amplitude decreased exponentially. They then evaluated a modified experiment in which the amplitude of the pendulum was (mainly) dissipated due to repeated collisions with an obstacle.

In (a)(i) the majority filled all five columns with their raw data, given to consistent and suitable precision, and calculated a mean. In (ii) some did not divide $A_{max} - A_{min}$ by two to give the uncertainty and a very few calculated a percentage but the impression was that many more knew how to do this than in 2010.

In (b) most gave three ratios, and of these, most produced three significant figure results in each case. Candidates are becoming familiar with the idea that they have to make a critical judgement about where their evidence supports a suggestion and in the majority of cases they felt able to confirm that an exponential pattern had been confirmed. Some centres are clearly giving their candidates criteria by which to make such decisions; several said that the deviation from the mean was not greater than 5% so they felt confident in accepting that their evidence as proof of the suggestion.

In (c) the examiners did not accept that the high rate at which data was being produced was a serious objection; there was no stipulation that the data had to be collected in one continuous sequence. Nor was it necessary to keep the initial displacement at 30.0 cm; once the position of the first rebound had been established, the pendulum could be held at that position and released.

Difficulty in establishing that the initial displacement was above the ruler was also rejected; the set square provided was sufficient to deal with that problem.

More popular and successful ideas involved the erratic nature of the rebound of the golf ball from the brick and the rapid decrease in the amplitude which produced larger percentage uncertainty and limited the amount of data that that could be recorded.

Here and elsewhere simple ideas could be poorly expressed; candidates that wrote 'because the amplitude decayed quickly the range of the results was small' gained no credit.

Candidates at the A/B boundary generally earned four out of six marks while E/U candidates typically earned two.

Question 2

Candidates were provided with a solar cell that was illuminated by light that had passed through two Polaroid filters. They investigated how the output voltage of the solar cell varied as one filter was rotated relative to the other.

The quality of the data was generally good and when plotted, these usually gave a smooth curve. However, many had already forfeited a mark by failing to give a unit with V_0 and a few gave V rather than mV. Examiners were watchful for errors in marking the intersection of the axes in cases where a false origin had been used. If not marked, the point of intersection is assumed to be zero so if a false origin is intended either the broken scale convention must be seen or the appropriate (non zero) value should be marked at the point where the axes cross.

The readings in (c)(i) were usually read correctly from the graph although some candidates used a plotted point that did not lie on the curve. In part (ii), others did not to divide the difference between the read-offs by two to give the amplitude; missing units here could forfeit the mark unless the same error had already been penalised in (a).

In (c)(iii) most knew how the graph told them about the sensitivity of the arrangement but many lost a mark by saying that this was when the ‘gradient was large’ or ‘steep’; examiners insisted on ‘largest’ or ‘steepest’. While many of the suggested values for θ were suitable some gave ranges for these values and this gained no credit. When more than one value was suggested it was often the case that the interval between these was not a multiple of 90°, as might be expected.

In (d)(i), the idea that the amount of light reaching the solar cell would be reduced so this would mean the voltmeter reading was lower was nearly, but not quite universal. However, once again poor writing obscured the detail that the examiners were looking for. ‘Filter blocks the light’ gained no credit (that is what filters do) and ‘less light reaches the filter’ was also rejected; there were two filters and it was F1, not F2, which received less light.

In (d)(ii) the examiners required a simple practical idea that did not involve any significant modification of the apparatus. The suggestion that when placed centrally on the scale the outline of the card containing filter F2 could be drawn on the scale and the position monitored as the card is rotated, was accepted. The use of the markings at either end of the arrow printed on the card was also given credit.

Candidates at the A/B boundary mostly earned six out of nine marks while E/U candidates typically earned three or four.

Section A Part 2

Candidates investigated how the output of a solar cell varied as the light, incident upon it, was absorbed by different depths of ink solution.

There were very few unit or power of ten errors in (a) and almost all took the measurements as directed in the question, taking five readings of *V* for *Q* between 100 and 200 ml and (at least) another five thereafter (until *Q* was about 500 ml). Those who referred to *V* as ‘voltmeter reading’, either in their table headings or on the labelling of the graph axes, were given no credit. Candidates should avoid using descriptive terms in table headings or as axes labels but should they decide to do so, they must ensure that the term they use properly represents the relevant physical property. It would be much better if they simply use the symbols defined in the questions to represent variables.

The significant figure mark for the raw readings of *V* was given in virtually every case but the mark for the derived readings of ln(V/mV) was not, as explained previously.

The graphical work of many A grade candidates was almost indistinguishable from that of E grade candidates, as should be the case because the conventions that we expect them to follow are well established. Despite this marks were lost for mislabelling the vertical axis (wrongly attributing a unit to the variable by omitting the bracket), for difficult scales and in the case of some drawn in landscape, a compressed vertical scale, or badly marked points and line. Given the difficulty some centres reported in producing a consistent inverse linear trend across the full range of Q, the best fit line was judged only where this trend was seen and credit was given when the distribution of points about this region of the graph was roughly the same above and below the line. Few scripts were seen where candidates had not drawn the straight line, as directed in the question.

The quality mark was another mark that most easily gained and was judged on whether at least 5 of the points between Q = 90 and 250 ml lay close to a straight line.

Candidates at the A/B boundary usually earned fourteen out of sixteen marks and E/U candidates generally earned twelve.

Section B

Question 1

No credit was given in (a)(i) if either read off was incorrect and full credit was withheld if the steps were of insufficient size. Some missed the negative sign with their gradient result or did not supply the minimum three significant figures that were expected but generally this was something most of the candidates could do.

In (a)(ii) three significant figures were also expected and credit was withheld if a unit was erroneously supplied. Candidates that chose scales that did not allow them to read off the intercept directly were required to use algebra to obtain the result. No credit was given for extrapolation of the line into the margin.

In (b)(i) the majority understood the form the ln(V) against Q graph would take and a majority explained that the gradient = $-\lambda$ and the intercept = ln(P). Fewer were careful enough in explaining that the line would be both straight and of negative gradient; both points were required for full credit to be given and answers in terms of $y = mx + c$ were not accepted.

Answers to (b)(ii) were rarely fully successful, most blandly accepting the analogy to be proven by stating that their graph produced a straight line. In some cases the evidence to justify this assertion was tenuous, at best and few referred to the plot for the initial reading, V_0, which usually fell well above the trend line. Some attempt to qualify the statement, suggesting a range of Q values for which the trend was linear, would have earned credit, but this hardly ever seemed to occur to the candidates. Attempts at quantitative comments usually proved to be little more than circular arguments in which gradient, intercept and a random value of Q were substituted into the equation for a straight line to predict V; this did little more than which confirm what was already apparent, ie that the line was straight.

Candidates at the A/B boundary usually earned four out of nine marks and E/U candidates generally earned three.

Question 2

In (a)(i) candidates were expected to describe simple practical difficulties only. The appearance of bubble sat the surface after the ink had been poured was popular as was the difficulty in reading the graduations on the measuring cylinder against the dark background of the ink but no credit was given for the statement that the meniscus was 'difficult to see'.

The answers to (a)(ii) were sometimes saved by a clear sketch, eg where the candidate had shown the eye level with the bottom of the meniscus. Otherwise, ideas such as 'viewing at eye level to avoid parallax error' or placing the measuring cylinder on a horizontal surface were accepted.

Many candidates were entirely successful in their answers to (b). In (b)(i) the idea that the graduations marked on the larger cylinder lacked precision was widely suggested and in (ii) most explained that the smaller cylinder would need to be used more than once to supply the larger increments of ink, thus adding to the time spent performing the experiment.

Candidates at the A/B boundary usually earned three out of four marks while E/U candidates generally earned two.

Question 3

Part (a) discriminated in favour of the more mathematically inclined and many completely successful answers were seen. There were two approaches to determining the number of slides equivalent to the half thickness, each requiring the constant λ to be found by measuring the gradient of Figure 5 to be calculated so that. Some, borrowing from the idea of half life, calculated the half thickness from $\frac{\ln(2)}{\lambda}$ while others calculated $\ln\left(\frac{V_0}{2}\right)$ and arrived at their result by $\frac{\ln(V_0)-ln\left(\frac{V_0}{2}\right)}{\lambda}$. A number of candidates tried the latter approach but made the mistake of assuming that they should determine N for the interval over which $\ln(V_0)$ halved and deduced that 202 slides were required.

In (b) those who wrote carefully generally obtained credit but careless writing was still seen, eg in (ii) it was common to find 'take multiple readings and calculate an average', the implication being that the same reading is taken repeatedly, which is not sensible; the readings taken had to be at different points on the slide or over a stack of several slides. In (iii) where a procedure to check for zero error on the micrometer was expected, several wrote 'check the reading with nothing in it' and another popular but unsuccessful idea was that the micrometer 'should be zeroed before use'; candidates who can not see why this is wrong should consider the action of the tare button on an electronic balance. The idea that the micrometer should be used to measure an object of known thickness was accepted.

Candidates at the A/B boundary usually earned at least four out of six marks while E/U candidates generally earned two.

Question 4

In (a) the idea that the slide thickness = $\frac{R_1-R_0}{12}$ was a popular distracter but a correct result for the refractive index was produced by nearly all.

In (c)(i) and (c)(ii) some missed the unit or gave the uncertainty as 0.02 m while in (c)(iii) some added the uncertainties before dividing by 1.47 but an encouraging number produced completely correct solutions.

Candidates at the A/B boundary typically earned four out of five marks and E/U candidates typically earned three.

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