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General Certificate of Education

Physics

PHA3/B3/X Investigative and Practical Skills in AS Physics

Report on the Examination

2010 examination - June series

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GCE Physics, PHA3/B3/X, Investigative and Practical Skills in AS Physics

General Comments

The candidates found this to be a more demanding paper than last year and Section B seems to have been the main factor in producing the lower mean mark and reduced standard deviation. There were very few high-scoring scripts but also very few poor examples; there seemed to be something in each part to allow candidates of all abilities to show what they could do. Clearly this group will have benefited from seeing the 2009 paper and the additional specimen now available however; this paper threw up new challenges that some found testing. The general impression gained was that the candidates were well prepared to meet the specific demands of the paper; techniques to construct tangents at a point on a curving best fit line, and the use of a mirror to avoid parallax error when reading a vertical ruler, were both well known.

Candidates' performance in Section A Part 1 was slightly poorer than in 2009 but this was mainly to do with question 2 which elicited very few completely correct solutions, even among the more able candidates; many at the E grade border were unable to score. There was little coherent understanding shown of how to represent the uncertainty in a calculation through the number of significant figures in the answer and, as this is an area of expertise that overlaps with the theory papers, centres should ensure that candidates are better prepared in future.
The more difficult processing involved in Section A Part 2 was intended to compensate for the less severe manipulative demands of the experiment compared with that in 2009. The standard seen here was broadly similar to that seen before except among the less able candidates who, in many cases, did appreciably better than last year. Nearly all the candidates at AS are well versed in the conventions of this style of question and the advantage demonstrated by the more able candidates over their less able counterparts in this part of the test was quite marginal.

In question 1 of Section B where candidates are required to analyse the evidence of their graphical work from Section A Part 2, many struggled last year but in 2010 even the less able candidates usually made some progress. However, there is still much that candidates even at the A/B boundary could do to improve in demonstrating the analytical skills demanded here; only the top 20% (scoring 40 or more out of 55) conveyed a really mastery of the tangent drawing and gradient calculations.

In question 2 where required to describe routine experimental procedures the candidates were well prepared and the standard seen was generally better than last year. The more able candidates took this question in their stride.

The candidates had opportunities to write at length (and most did, exemplified by the profusion of supplementary sheets) in the other questions in Section B and both of these discriminated well. In the 2009 paper two high tariff questions involved straightforward data analysis but in 2010 the emphasis shifted towards the use of extended writing supported by calculation (question 3) and planning an experimental procedure (question 4). Here again, the top 20% performed significantly better than the rest but the work of the A/B candidates was distinctly better than that of the E/U candidates who typically struggled to provide coherence and structure in their writing.

The accounts offered by less able candidates tend to feature generic responses such as 'reduce uncertainty by using instruments with more precise scales' or 'repeat results and calculate a mean' but usually overlook the need to generate a range of data so that a solution to the problem can be reached by means of a graph. The indifferent quality of some extended writing highlights another area in which the questions posed in theory and practical papers overlap and where a shift in emphasis in the preparation of candidates might prove beneficial. It was clear where centres had taken note of the PSV exercises in the preparation of the candidates. There was plenty of evidence that candidates understood routine precautions to reduce uncertainty when measuring diffraction angles and many were able to make some progress in describing how a diffraction grating could be calibrated. The grating formula was well known and it was rare to find this confused with the 2-slit formula. However, few scored more than two of the four marks available because they did not say enough to earn the full quota of marks available; candidates should pay attention to the subtotals showing the mark allocations and use this to judge the depth and detail of their answer.

Section A Task 1

Candidates were required (in question 1) to use a diffraction grating to observe the diffracted images of a vertical slit illuminated by light from a bicolour LED. They then made measurements (in question 2) on a Moiré fringe pattern produced when two grids of ruled lines were overlaid. The candidates seemed to have little difficulty in carrying out either experiment although the quality of the data produced in question 1 was significantly better in most cases than that produced in question 2.

Question 1

In parts (a) and (b) of question 1 the raw data recorded showed that the arrangement had been correctly set up and the experiment carried out as intended. Some lost marks by recording some or all of the data to the nearest centimetre or by failing to supply any appropriate unit. It was encouraging to see that the majority had made repeated measurements to determine x_G and x_R (even if this was not explicitly shown, it was assumed that the measurements given were to the left and to the right of the centre of the slit).

In part (c) (i) many less able candidates forgot, or did not know, to use the $(\tan)^{-1}$ function with their value of $\frac{x}{y_2 - y_1}$ to compute the angles θ_G and θ_R. It should have struck them that the results they obtained were not sensible but such candidates may not appreciate the need to inspect numerical results before moving on. Failure to score in (c) (i) did not affect the chances of success in (c) (ii) and many obtained both of the available marks. Some truncated their result to 1.1 while others needlessly supplied a unit.

In (d) the majority explained how rearrangement of $n\lambda = d \sin \theta$ could lead to a determination of the grating spacing and that they would need to know the wavelength in order to complete the job. This was not enough to earn all four marks. More able candidates mentioned that the use of higher orders or increasing the slit to grating separation would reduce uncertainty but very few gave really convincing suggestions about improvements and the idea that use of ‘a more precise ruler’ featured in many poorer scripts.

Question 2

For most the question unravelled at the first hurdle because they did not do the simple part properly and it was a major surprise to discover how many tried to determine p, the spacing of the lines on the grid in Figure 4 by measuring across three or even single lines (it was expected that candidates measured across a minimum of 10). This frequently led to a one significant figure result for p. While the measuring done to find D, the spacing of the Moiré fringes, often led to a plausible result of about 34 mm, very few then got a sensible result for $\frac{D}{p}$, either because p was to one significant figure, or because they truncated their answer and/or wrongly gave a unit. The explanation required in (b) may have undermined their thinking but even so, very many seem not to know that the number of significant figures given in the result of a calculation must be the same as that in the data with the fewest figures. Many referred to the precision of the ruler used when explaining themselves and few appreciated it was the derived results for p and D that should inform the decision. The thinking should have been that if p and D had been obtained by measuring over sufficient intervals, the values obtained could each be reasonably given to three significant figures and then so too could the result for $\frac{D}{p}$.

Section A Task 2

Candidates were required to investigate the bending of a plastic metre ruler under its own weight.

Most candidates earned the mark in part (a), exceptions being when candidates gave a result for h_0 that suggested that the free end of the ruler was above the clamped end, although some forgot to supply the necessary unit. Values of h_0 not given to the nearest millimetre lost the significant figure mark in part (b).

In part (b) it was noticeable that there is a trend among the candidates to write a description of the variable in the table headings (and on the labels to their graph axes). The examiners will not penalise this practise providing that the label makes sense, but it is a clumsy and illogical thing for the candidates to do and should be discouraged. Examiners prefer the identifying symbol, eg x, with a suitable separator, ideally the solidus, and a valid unit in the heading of each column of the table, thus x/mm. The tabulation (T) mark is probably the easiest to earn in the paper yet some missed out by ignoring the instruction to tabulate the independent (x) data in the left-hand column. Having been instructed to construct columns of data it is odd to see that some still tabulate their data in rows.

The results (R) mark was a good discriminator; while most took note of the need to produce a total of six different sets (five in addition to the initial set where x = 900 mm) it was the identity of these additional sets that attracted the examiner's interest. Candidates that chose equal x intervals between x = 900 and x = 0 mm produced graphs with insufficient detail where ($h - h_0$) was changing most rapidly; those that saw the need to keep the gaps between ($h - h_0$) values from becoming too large also needed to ensure that a sufficient range of x values were produced. The ideal compromise was that x intervals of 100 mm were chosen so that the smallest value of x was 400 mm (by this stage the gaps between ($h - h_0$) values had become small. The fact that so many candidates took this route suggests that they were thinking along the same lines. Candidates were required to have at least four sets where x was at least 500 mm (and a range of x values of at least 500 mm) so those that picked x intervals of 150 mm lost one mark for results.

There is something in the mindset of candidates that tells them that it is acceptable to write down truncated values for the independent variable because they have made the choice as to what these values should be; it was usually the *x* values that were given to the nearest centimetre when the significant figure mark was lost.

The same mindset seemed to drive the candidates that had chosen *x* intervals of 150 mm to produce graphs with difficult horizontal scales (major intervals going up in multiples of 150). These candidates need to appreciate that difficult scaling makes others' interpretation of the graph much more difficult. The vast majority of plotting errors that are discovered arise because of the use of difficult scales and this is equally true where marks are lost due to the incorrect transfer of data between the graph and a gradient calculation. The other common error is where the origin is needlessly included, compressing the useful area of the grid available; this was a commonly found where candidates had used *x* values between x = 900 and x = 500 mm.

When all candidates accept the need to choose scales that make good use of the page and are also convenient to use, the distinction between A/B candidates and E/U candidates will become even smaller than it already is for this section of the paper.

The Q (quality) mark, awarded for six points plotted that produced little or no scatter on the graph was earned by most, so the key area of discrimination was often the quality of the line drawn. Many candidates cannot draw a smooth curve; successive short straight sections are not acceptable, nor are lines that do not distribute scattered points evenly to either side. The need to practise the art of curve drawing was also highlighted by the number of sketchy, thick or faint lines for which the examiners withheld marks.

Section B

Question 1

In question 1, the candidates were required to perform further processing on their graphical work in Section A Task 2. They were required to measure the gradients, G_1 and G_2, of their graph at x = 750 and x = 650 mm. This is not an easy skill but it was encouraging to see how many knew the technique in which a plane mirror is used to construct the normal at a point on a curve from which the gradient can be calculated. Possibly because less space was afforded on the question paper, some did not always show clearly how they arrived at their result for G_2, although the working for G_1 was often enough to confirm that the candidate had transferred data correctly between the graph and the calculation. Where full credit was withheld it was usually because the steps in the gradient calculation were not sufficiently large. The less able candidates continue to struggle with gradient calculations; some used plotted points at x = 750 mm and 650 mm to calculate G_1 and G_2 and others inverted the calculation, taking x-step over ($h - h_0$) -step.

Relatively few candidates gained success with the calculation of $\frac{G_1}{G_2}$, the outcome being sensitive to the directions of tangents drawn.

Except where an incorrect method had been used to determine G_1 and G_2, most were able to gain a mark in (c) for explaining that they had drawn a tangent (or normal) in order to arrive at their answers.

Question 2

Part (a) was done well by nearly all, although it largely depended on how closely previous *Reports on the Examination* had been read as to whether the candidates knew how to earn both marks and said that the set square should be used on two perpendicular faces of the vertical ruler. Many centres had prepared their candidates well for part (b) and there were few who did not appreciate that the error that was to be overcome was due to parallax. Many of the sketches given were clear and showed all the detail the examiner needed to award full credit. However, other sketches were seen that not only cast doubt on the arrangement that had been used but also cast doubt on the ability of the artist to communicate even the simplest idea in graphical form. There is a serious issue here for future candidates to address; the ability to illustrate an idea or describe a process with a simple sketch is a core skill that centres should work to develop in their students.

Question 3

The answers to part (a) were, in many cases, improvised, but were none the worse for that. Candidates saw that a key issue was to do with the precision of the proposed microscope and took note of the instruction that they should illustrate their answer using suitable calculations. It was also obvious that here, more candidates (in contrast to question 1 (d) of Section A Part 1) took note of the mark subtotal and geared their answer to making two relevant points, each suitably illustrated.

Those who thought carefully about the problem posed in part (b) realised that measures to reduce uncertainty in one variable can have a detrimental effect on another and saw that the proposed change in D would make α far too small to be measured reliably.

It was interesting to compare the answers to part (c) with question 2 from the 2009 paper which also required candidates to calculate percentage uncertainty. As last year, there are still many that cannot do this type of calculation in a wholly transparent way and a lot of scripts were seen where an apparently correct answer was arrived at by an incorrect method; where the value 0.0855 was given in the denominator of the working, no credit was given.

Question 4

More alert candidates used the bullet points to structure their responses to part (a) and marks were often earned for identifying that a ruler would be required to measure dimensions d and l. Some also claimed that a ruler would be needed to measure the extension, Δl, rather missing the point that it was only using the optical technique outlined in the question that such a small extension could be calculated. The need to calculate Δl was needed to unlock access to the upper range of marks, together with the idea that the stiffness, k, could only be found dependably if the extension was calculated when a range of forces was to be applied to the strip. Thereafter, a graphical approach could reveal the value of k. If it was not made clear that the force applied to the strip would be varied, no credit was given for suggesting that a graph would be drawn. Despite the usual plethora of generic responses to how uncertainty could be reduced, some good ideas emerged such as finding d by measuring across several fringes at once and using a longer strip to reduce the uncertainty in l.

In part (b) many saw that using the technique outlined in (a) to measure the stiffness of the ruler would be fruitless because the extension produced would be far too small to cause significant changes in d. Credit was also given if the candidate said that the force needed to produce a significant extension of the ruler would be too large to be practicable.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results statistics page of the AQA Website.