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Physics PHA3/B3/X

Unit 3: Investigative and practical skills in AS Physics

Report on the Examination

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

General Comments

The 2012 AS EMPA performed in a similar fashion to 2011; the weaker students may have found a little more that they could do but all the questions discriminated well. There was more manipulative challenge in Section A Part 2 where the students had to use two different approaches to determine the values of x_1 and x_2 but nearly all proved equal to the task. The extent to which some students threw themselves into this task was evident from the amount of data recorded but this often lacked coherence, results often presented in sets and in no particular order. In most cases a simple table summarising the work and listing the data to be transferred to the graph would have clarified matters. The examiners will withhold tabulation marks for badly presented work and this is an issue Centres should address with their students; the variation in the marks for Section A Part 2 at A2, where the students have largely got to grips with the issue of working transparently, is much less than at AS where many students unnecessarily penalise themselves.

Likewise, there is significantly more variation in the quality of graphical work at AS than at A2. Many of the AS students needlessly included an origin not only in Section A Part 2 but also in Section A Part 1 question 2 penalising themselves twice over. There were others who spotted the need to use a false origin but did not mark this properly; where the intersection of the axes is left unmarked the examiners will take this to be the true origin (i.e. (0, 0)) and if this implies a non linear scale marks will be deducted.

Students should be more methodical about checking errant plots; there were many instances where a single point stood out but was not checked and the line had been chosen to accommodate such points when the evidence clearly pointed to their exclusion; students should know that such points instantly attract the interest of the examiners and will cost a mark if found to be wrongly plotted.

Three of the five PSV exercises featured in some way in the test; in Section A Part 2 students investigated the trajectory of a ball bearing and in B3 they described a circuit used to produce an *IV* characteristic and discussed how the dimensions of a uniform conductor affected resistance. The assured use of the relevant formula showed that the students were well prepared.

A new idea this year was testing whether students could distinguish between some common empirical relationships (Section A Part 1 question 2); some clearly feel that any negative correlation qualifies as inverse proportion while others do not know that a straight line of negative gradient can still be direct proportion.

The number of students entered for this year’s EMPA has increased significantly but there is no sign that this has made much impact on the ability spectrum and the continuous writing was at least as good as that seen in previous years.

Section A Part 1

Question 1

In question 1 the students made measurements on a 10p coin. The marking of part (a) followed the pattern of the equivalent question in last year’s test. Then, as here, some students arrived at answers for the diameter, *d*, of the coins that were 0.5 mm in error through misreading the sleeve (fixed scale) part of the instrument.

In (b)(i) the tracks produced showed that students had often used the full width of the slot provided in which the coin was rolled but they often used only small sections of the track to find the ridge separation, *s*. Many were successful in obtaining an acceptable answer for *s* but did not get full credit for measuring across at least 50 ridges. Others spoiled their answer by truncating the result to 0.8 mm which impacted on the answer to (ii).

In (b)(ii) the use of $\frac{\pi d}{s}$ to obtain the number of ridges on the coin was almost universal and there were many completely successful answers.

This question provided excellent discrimination and there was a good representation of students at each of the marks in the range. Students at the A/B boundary usually earned 3 or 4 marks out of 6 while E/U students generally obtained 2.

Question 2

Students investigated a resistor made from two pieces of conductive paper. Students were required to use a digital Ohm-meter, an instrument that had not been used in the EMPA before, but no script was seen where this was not used properly.

The question tested deductive reasoning based on the evidence of a graph and making predictions about alternative outcomes. Once again, this question discriminated very well.

Many struggled to get both marks in (a). Some failed to use an adequate range of *x* values (at least 250 mm was required) but the most costly error was the lack of precision with which these values were recorded. Students seem to think that when recording data for the independent variable, the exactness of the values must be perfect since in choosing the relative position of the two parts of the resistor most set these to match major divisions on the ruler; giving all the *x* values to the nearest cm was a frequent error; others insisted on recording the same number of significant figures for each value of *x* (implying that the precision increased by a factor of ten once the reading fell below 100 mm).

In part (b) only those who had measured *R* over a very compressed range of *x* values, thus getting significant scatter, failed to produce six points that lay along a good straight line. Marks were lost for poor vertical graph scales that included the origin but the wrong marking of a false origin or the use of a difficult scale also cost this mark. An errant point, unchecked by the student, often led to the examiner detecting a misplot but there was also a profusion of badly marked points and/or lines that led to the loss of the second mark. It was rare to find scripts that were awarded all four of the marks available in parts (a) and (b).

A majority recognised that 'linear' was the correct choice in (c)(i) and unless this was the case no marks were awarded for (c)(ii). In (ii) students were expected to state that a straight line trend (eliminating inverse proportion) and the failure of the line to pass through the origin (eliminating direct proportion) informed their decision. Some said that the line they had produced was of the form $y = mx + c$; as this implies a constant gradient we gave the 'straight line' mark but withheld the second mark unless $c \neq 0$ was added.

A few students said that the negative gradient eliminated direct proportion but they if they go on to A2 they will realise that the defining equation for simple harmonic motion destroys their argument.

In (d)(i) the use of $R = \frac{\rho l}{A}$ got most answers off to the right start and these usually went on to correctly predict that the resistance would increase if the width of the conductive paper strips was reduced. Failure to use the formula meant that students had to be careful about how they defined *A*; we rejected 'contact area' and 'surface area' insisting that it was 'cross-sectional area that decreased when the width was reduced.

The dilemma as ever in (ii) was to decide how the impact on *R* affected the gradient of the graph. Had they held on to $R = \frac{\rho l}{A}$ where most started their argument they would have seen that the reduction in width would produce a fractional increase in *R* and hence an increased gradient but it seemed that most were content to guess this answer and there was a roughly equal split between those that got the correct outcome and those that said the line would shift upwards but the gradient would stay the same. Some talked themselves out of this last mark by reasoning that a more negatively sloping line would have a (numerically) smaller gradient.

For students at about the A boundary a typical mark was 8 out of 10 and students at the E boundary often scored 3 or 4. There were very few completely successful scripts for this question.

Section A Part 2

Students were required to investigate the trajectory of a ball bearing.

In part (a), the initial values of *H* and *h* were almost always given credit although failure to record either of these to the expected precision cost the significant figure mark in (b). Whether or not the recorded values were accurate could not be judged until they had been incorporated into the calculation in B1.

In (b) the students had to arrive at a sensible value for x_1 based on (presumably) several impact marks, then change tack and arrive at a satisfactory value of x_2 by a trial and error method. This resulted in a plethora of x_1 values accompanied by a single x_2 value for each position of the track.
It was concerning to find so many sprawling records of untabulated results. Some students set out their results in sets and x_1 and x_2 values became disconnected and units lost. Marks had therefore been deducted for poor tabulation. Centres need to do more to instil in their students the understanding of the need for transparency and order in the recording of data and we will consider how to tighten marking guidelines to penalise those who transgress.
The results themselves did usually show that an adequate range of x_1 values had been taken and it was rare to withhold the SF mark for unsuitable or inconsistent precision.

In (c) despite the unpromising appearance of many sets of data, the end product of the work was often excellent with many graphs with good straight line trends. Graphs did not always attract full credit and the reasons for this have been discussed in the first part of this report. However it is appropriate to remind Centres about the acceptable intervals on scales. Scales should not be chosen simply to drive the points at each end of the range to the margins of the page; the choice of a scale is a compromise between maximising the use of the page and making the work transparent and easy to interpret. We currently accept scales based around intervals of 1, 2 or 5 and (unlike the ISA) we reluctantly accept those based around intervals of 4 although this will be reviewed before next year. Students who base their vertical and horizontal scales around different intervals significantly increase the likelihood of plotting errors.

Students producing work of A grade standard here are those who are more careful, organised and have been made conversant with the conventions of the technical nature of this section of the test. They are not always the best students, as some of the continuous writing in other parts of their script shows, but they are getting full value for their efforts and this has a big impact on the overall outcome in their favour. These students usually earned 12 or 13 out of 15 marks for this question (much as in 2011) while E/U students generally earned 10 or 11 (indicating that these students found this part of the test slightly more accessible than in 2011).

Section B

Question 1

The use of small triangles cost some marks in (i) and Centres should be aware that any read-off error negates both marks for the gradient calculation.
Besides the technique of gradient calculation, this question generates a numerical outcome to test the overall accuracy of the experimental work done in Section A Part 2 and it was gratifying to see many answers to (ii) that were close to the theoretical value. It was only occasionally that an answer was spoiled by the incorrect inclusion of a unit.

Students at the A/B boundary generally earned at least 3 out of 4 marks while E/U students earned 2 on average although a significant number of these could get no credit.

Question 2

Some Centres had provided improvised plumb lines and in their answers to (i) their students referred to ‘a weight on a string’; this was accepted but any reference to the use of ‘a pendulum’ was rejected.

In (ii) we rejected the suggestion that mark C had resulted from the wrong initial placement of the ball on the track; such an error could have not produced an increase in the horizontal displacement shown by this mark. Likewise the notion that the ball had been given an ‘extra’ push was given no credit since the ball should have been simply released from rest.

In (iii) the overwhelming majority rejected C and used the remaining impact marks to deduce that x_1 should have been recorded as 584(.2) mm.

In (iv) many knew that they should give half the range, continuing to omit C as anomalous.
The question provided excellent discrimination between A and E grade students.

Students at the A/B boundary generally earned at least 6 out of 7 marks for this question while E/U students typically earned 2 or 3.

Question 3

The diagram in part (a) usually showed an ammeter and voltmeter appropriately arranged but the means to vary the pd across the pencil, essential in the production of an *IV* characteristic, was missed. Some used non standard symbols (a thermistor appeared on several scripts) and others inexplicably connected a wire between the crocodile clips and forfeited both marks.

Part (b) caused problems for nearly all students since the behaviour of the graphite is the mirror of that of the filament lamp so required a leap of faith if they were to say that the resistance decreased as temperature increased. Many got off to a good start by explaining that an increase in current caused the temperature to increase; those who said that the temperature increase drove the increase in current lost this mark. The arguments frequently then took a path relating the gradient of the graph to the reciprocal of the resistance but this gained no credit since the graphite is not an Ohmic conductor. Those that tried to argue that the current increased faster than the pd were similarly unsuccessful. Answers that talked about increasing numbers of delocalised electrons as the temperature increased did not address the question which specifically asked about how Figure 9 explained the link between resistance and temperature. Thankfully, good students did trust their understanding of the situation and correctly predicted the relationship between temperature and resistance but it was very rare to find an answer that successfully linked the first and third marking points.

Part (c) was a mixed bag with relatively few completely successful answers. Many pushed the line through the origin and lost the first mark while others failed to take large enough steps to calculate the gradient, or having drawn an intercept, failed to take account of this when calculating the gradient. The final answer was often in range although there were some who inevitably had power of ten errors by failing to take account of the units on the resistance axis and others who gave the answer to more than 4 significant figures.

Part (d) was easier if the argument started with $R = \frac{\rho l}{A}$ which was usually followed by $A = wt$ and rearrangement to give the relationship for resistance per unit length. Some worked backwards but these attempts were also nearly always successful.

Answers to part (e) were disappointing. Many said that the measurement of the width of the paper should be carried out using a micrometer, seemingly unconcerned that the paper could never provide the resistance needed to cause the ratchet to engage. Vernier callipers and rulers were accepted as a means of making the measurements but the detail given thereafter about reducing uncertainty was usually insufficient; we required repeated readings at different points and calculation of a mean for one of these additional marks, and some method of ensuring that the measurements were made perpendicular to the edge of the strip for the final mark.

Difficulties with parts (b) and (e) meant that very few could earn more than 11 out of 13 for this question. Students at the A/B boundary often earned 9 marks while E/U students typically earned 4 or 5.

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