A-LEVEL
PHYSICS

7408/3A
Report on the Examination

7408
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General Comments

Pleasingly, the mean mark for the paper was slightly higher than in 2017 and the students found these problems, particularly question 1, more accessible than those that were set in 2017.

However, some of the underlying problems seen on the 2017 paper still persist. Misuse of technical vocabulary is still widespread, with many students referring to balances as ‘scales’ on which mass is ‘weighed’ in question 03.3. In 02.1, many stated that their ruler was ‘straight’ when they should have written ‘vertical’. Elsewhere, slipshod use of basic language proved costly, for example in question 01.6 where some students described a sequence of steps that were probably unintended. Students continue to improvise when required to describe practical procedures, suggesting that their experience of laboratory work is mostly confined to meeting the demands of the 12 required practical activities. In 02.1, few could explain simple steps to measure the sag of the tape measure.

More encouragingly, many students wrote in question 01.6 with confidence, structuring logical and coherent responses to the experimental design exercise and, in many cases, earning full credit. In contrast to the work seen in 2017, better solutions to multi-stage calculations were seen, the best example being in question 03.6, although many were also able to make some progress in questions 01.3 and 02.4. However, disappointing numbers of students remain oblivious to what an integer is (question 02.3), or how to express the order of magnitude of a number (question 02.5). Students should be discouraged from showing intermediate results in fractional form as this reduces the transparency of their work. The quality of the graph work in 03.4 was mixed, with many students choosing a poor scale.

There were signs that students were realising the intentions of questions better than in 2017. In question 01.2 they spotted the detail needed to deduce the direction of the magnetic field, but in 01.5 the significance of the currents in X and Y having the same magnitude went unnoticed. Too many answers to 02.2 failed to take account of how the diminishing vertical deflection impacted on percentage uncertainty in *y*.

The students’ knowledge of most of the core physics was generally sound. Most knew the assumption examiners were looking for in 01.1, although few could give both conditions to justify the application of Charles’s Law in 03.2.

Question 1

This question addressed some of the ideas behind required practical activity 10.

01.1 Much of the working seen convinced examiners that the students had taken moments about the pivot, although some used 30.0 rather than 29.0 in the calculation. A few forfeited a mark by rounding their result to two significant figures. Weaker students attempted a solution based on proportions of the balance reading shown in Figure 2, while others simply copied the balance reading on to the answer line. While some stated the assumption they made was that the ruler was in equilibrium, examiners were looking for a statement implying that the ruler was uniform or that the centre of mass was at the 50 cm mark. Significant numbers of students gave a creditworthy assumption although those that stated “the ruler has uniform density” or “the mass is in the middle” were unsuccessful. Just over two-thirds of students scored at least one mark.

01.2 The key failing of some students here was (surprisingly) that they seemed to think that the current direction was self-evident and not worthy of comment, even if they had correctly deduced the direction of the force (despite some tying themselves in knots with Newton's third law). Some students relied on the examiners spotting relevant annotation made to Figure 3. Statements that the current was 'from positive to negative' or 'clockwise' were not accepted. Unless the directions of the force and the current were both stated, no credit was given for stating the direction of the field. Logically correct deductions, based on incorrect force and/or current directions, could score as long as the left-hand rule was mentioned in support. For these reasons, approximately a third of the students scored one of the three marks and nearly another third scored zero. Thankfully, 17.1% gave a detailed, fully-justified and correct response earning full credit.

01.3 Most students recognised that they should find the gradient of the graph in Figure 4 to score the first mark, although a minority predictably failed to spot at least one of the false origins. Some mistakenly thought they should use the information in Figures 2 and 3, and others thought σ was the value of M when the current was 1 A. Correct use of 9.81 earned the second mark for many. While few students failed to correctly insert 5 cm into their calculation for B, most struggled with the various power of ten issues. This discriminated strongly in favour of the better students who could expect to score at least two marks.

01.4 The first row of Table 1 attracted the most correct responses and thereafter things got patchier. Examiners needed to see correct responses in both row 3 and row 4 to earn the third marking point; this proved beyond all but the most able, with only 11.4% obtaining full credit.

01.5 The need here to get the currents in X and Y travelling from left to right was met in most, but by no means all, solutions by drawing a parallel circuit. However, to guarantee that the currents had the same magnitude, X and Y needed to be in series. This involved a figure-of-eight arrangement; the subtlety of this was lost on all but 7.9% of the students. The majority of diagrams were drawn freehand and were often untidy so that, in some cases, gaps were left and no credit could be earned. The addition of superfluous detail such as a voltmeter sometimes led to unworkable circuits. A surprising proportion of students (11.5%) did not attempt this question.

01.6 This was for many the most successful part of the paper, so much so that most students ran out of space in their enthusiasm to set out their solution. There were four marks available for outlining a suitable strategy and students could earn any three of these for maximum credit. In common with the approach on paper 7407/2, examiners insisted on seeing that the dependent variable, correctly identified as m or F, was 'read', 'measured' or 'recorded'. These are the terms examiners expect students to use if similar questions are posed in future papers. Students were split on whether the perpendicular distance d or the current I would be the independent variable, but were nearly universal in their conviction that the balance reading would be the dependent variable. Despite being told that the pan of the balance moves a negligible amount during use, a few students decided that in varying I they could make d the dependent variable. Some students penalised themselves by overlooking the need to measure the length L of wire X. Others failed to clearly identify the remaining control variable and to state that this too should be measured. A few students thought the balance read the vertical force F directly, but many correctly saw the need to introduce g. The analyses given were impressive and varied; most could explain a relevant graph with m or F involved somewhere on the vertical axis. Examiners took statements such as "plot F against I^2" to mean that F was the dependent variable and would be plotted on the vertical axis, otherwise the use of the gradient to find *k* could not be verified. Most students gave an expression to show how their gradient could be manipulated to obtain *k*; examiners expected *k* to be the subject of this expression. There was strong representation at each mark for this question, from zero to five; 16% of students obtained full credit for their answer.

Question 2

This question addressed the general practicalities of making measurements (which was conspicuously poorly-answered in 2017) and use of log graphs to discover power laws.

02.1 Two approaches were seen for obtaining the vertical distance *y*. The indirect approach involved measuring the height of the tape (from the floor) at the free end and subtracting this from the height of the bench. The two measurements involved required the use of a vertical ruler and how this was to be achieved was widely ignored. Examiners were looking for the use of a set-square in contact with the ruler and the floor to make the ruler vertical, a detail that could easily be provided if the students added detail to Figure 7 as was suggested. That so few chose to follow this advice explains why barely 10% were able to score both marks. Another suggested method employed a horizontal reference, established by laying a straight edge along the bench to overhang the free end of the tape. A ruler (made vertical with a set-square) could then measure *y* directly. Those students taking this route were more prepared to add detail to the diagram, but often showed the straight edge failing to reach the bench or omitted detail involving the set-square. Other approaches, where safe and relevant, could earn credit, such as the use of a plumb line or spirit level. Those who suggested using bits of string, lasers or trigonometry did not gain credit. Disappointingly, nearly half of the students failed to gain any credit for their answer.

02.2 Many students identified that *y* would become very small if *x* was less than 70 cm but barely 10% correctly stated that this made the percentage uncertainty in *y* unacceptably high.

02.3 All of the marking points discriminated well but not always in combination, so only 10.2% of students scored all three marks. The line quality was usually good, but examiners expected the line to pass above the first and below the sixth points: a surprising number of students drew their line passing through or below the first point. The result of the gradient calculation usually fell within the expected range, but those who truncated it (usually to 4) were penalised. In addition, those who copied their gradient result onto the answer line for *n* failed to recognise that an integer was expected, so they too failed to score.

02.4 About half of the students correctly stated that log *A* was the (log) *y*-intercept and many then correctly explained how, having obtained the intercept, they could calculate *A*. A few spoiled their answer by using base 10 for the first point and base *e* for the latter, and others, anticipating 02.5, stated that they would use data from Table 2. With a three-mark tariff, it was surprising how few students provided detail of how the intercept could be calculated indirectly, a comparatively easy process to describe if done carefully. Over a third of students scored two marks, but very few (4.3%) scored all three.

02.5 The work seen here was sometimes very good and two-thirds of students could at least produce a suitable value for *A*. The problem for many was identifying the order of magnitude (most simply copied their result for *A* onto the answer line). To a lesser extent, many struggled to identify the unit, particularly when a non-integer was given for *n*. For a typical value of *A*, using the top row in Table 2, a result of 1.99×10^{-7} was routinely obtained. Examiners accepted –7 or 10^{-7} for the order of magnitude and cm^{-3} for the unit. A non-integer *n* such as 3.3 would produce $A = 6.09 \times 10^{-6}$ so the order of magnitude is –5 and the unit $cm^{-2.3}$. As with question 02.4, all the marking points were accessible, but it was unusual to see all scored together; just less than 10% gained full credit.

Question 3

This question addressed some of the ideas behind required practical activity 8.

03.1 Many students stated that the volume of air in 9c was less because water had entered the flask, but the better students realised that the expected response was that the pressure of the air had increased. Only 16% qualified their answer by adding that the temperature was the same for the situations in 9c and 9d, or that Boyle's Law could be applied. Some disqualified themselves by stating that air entered the flask as it was raised. Knowledge of the gas laws seemed generally patchy, with only approximately 40% of students making progress with this question or with 03.2.

03.2 Many answers suggested that Charles's Law was even less well understood than Boyle's Law. Only the better students realised that they were being asked to give two conditions that should be met if Charles's Law is to apply. While some correctly stated that pressure must remain the same, only 7% added that the mass of gas must be constant.

03.3 The direct and the indirect approaches to finding the volumes proved equally popular, but a small minority of students tried unsuccessfully to use some variant of the gas laws. Examiners expected a measuring cylinder to be used for the direct method and wanted students to explain that the reading was taken with the eye level with the bottom of the meniscus to avoid parallax error. Very few could give a completely correct response. For the indirect approach, examiners gave no credit for 'scales' rather than 'balance' (the instrument had been clearly identified in question 1) and rejected the idea that mass could be 'weighed'. However, many students gave a sensible way to account for the mass of the flask when determining the mass of water and could explain how the volume was obtained, as the density was known. Examiners did not allow "1 g = 1 cm^3", variants of which were seen rather too frequently. As with question 01.6, students frequently wrote more than they needed to, yet the number scoring all three marks (5.1%) was disappointing.

03.4 Many students plotted (19, 48) which probably saved the graph scaling mark but ruined their chances of earning full credit in question 03.6. Those plotting the correct (19, 207) and (86, 255) often chose to include the origin, compressing the scale. A minority plotted (19, 255) and (86, 48), producing a graph with a negative gradient. Nearly 60% of the students scored at least two marks.

03.5 The lines drawn were of mixed quality. Unfortunately, some students forced the line through the origin. Examiners expected the line to pass through both plotted points, yet over 40% of students were unable to score.

03.6 The work here was sometimes very good and usually easy to follow. Even when the line had been drawn to pass through (19, 207), producing a small positive value for absolute zero, the students tried a logical approach to the problem and duly gained some credit.

Clearly at this point, the students who had produced a graph with a negative gradient should have been asking themselves some serious questions, so it was disappointing to see how few revisited question 03.4 rather than optimistically writing down –273. Students need to be reminded they should inspect their work before moving on. Those who did everything right but omitted the minus sign with their result would be annoyed by their oversight. Over half of the students made some progress and more than 20% obtained full credit.

Mark Ranges and Award of Grades

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