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(9630) PH03 Fields and their consequences
Report on the examination

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REPORT ON EXAMINATION: INTERNATIONAL A-LEVEL PHYSICS (9630) PH03 FIELDS AND THEIR CONSEQUENCES – JANUARY 2022

This paper consisted of a range of questions assessing all four assessment objectives. The style and demand of questions were consistent with those of previous series. Students had many opportunities to demonstrate their knowledge and understanding on a variety of topics.

Mathematical questions were often answered well although there is evidence to suggest that many students take insufficient care with detail. For example, rounding errors were surprisingly common, and the formation of the numbers themselves was occasionally unclear. Benefit of the doubt is at the discretion of the examiners and students who write the number "9" as a letter "P", for example, may lose marks.

Many students found questions that required extended writing and the use of precise scientific language challenging. Often answers were either ambiguous or unclear and were therefore not rewarded. Some students also failed to reach the standard of technical language or depth of analysis expected at A-level.

In terms of assessment objectives, students generally performed well on questions that assessed AO2 and the data analysis aspects of AO3. Performance in AO4 was more variable. Performance in the evaluative aspects of AO3 required clarity of writing and many students struggled to express themselves sufficiently clearly.

SECTION A

QUESTION 01

The majority of students completed the calculation in 01.1 without any problems. Those who found it more challenging were usually able to pick up partial credit, with marks from 0 to 3 all being seen.

Question 01.2 was more challenging. It was clear that some students did not identify that the total energy was constant, and drew a curve. Partial credit was given when their peak was at 0.235 mJ.

The calculation in 01.3 was straightforward and carried out correctly by most students. In common with other "show that" questions, students are penalised when they do not make it clear which equation they are using, or if they give an answer to insufficient significant figures.

To answer question 01.4 students had to identify the displacement when the elastic string was unstretched. It was common to see students assume that the load was in the equilibrium position giving a displacement of zero. Partial credit was given to students who made this error but clearly used the time period or the amplitude to obtain their answer.

Many students answered question 01.5 by simply quoting the conditions for shm. The suggestion that the acceleration was no longer towards the equilibrium position was incorrect. Students who realised that the acceleration was now constant (9.81 m s^{-2} downwards) and no longer proportional to the displacement were given full credit.

In 01.6, there was only one mark for identifying that Y must have the greater stiffness when it was accompanied by some correct physics. The discussion had to go beyond merely quoting the time period equation for a mass–spring system. Few students were able to make any progress with this question.

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QUESTION 02

The calculation in 02.1 resulted in a good spread of marks and discriminated well. It was pleasing to note that students did not simply stop at the end of the calculation but completed their answer by making a relevant statement about whether the water was unsafe to drink.

Question 02.2 required students to support their answer with some relevant analysis. Vague answers that simply compared the half-life with the residence time did not gain credit. An answer to this question at the full A-level standard requires students to make quantitative use of the data given to them.

Although the majority of students received full marks for 02.3, it was common to see students failing to gain marks by making mistakes unnecessarily when converting between years and seconds.

QUESTION 03

In order to get the mark in 03.1, students had to make it clear how the combination of the current direction and the force direction indicated that the magnetic field was upwards. Few students provided answers with both these details.

03.2 was one of the most accessible questions on the paper. Almost all of the students obtained the one mark for the calculation.

The multistep calculation in 03.3 gave a good range of marks and differentiated well. Although the gain in gravitational potential energy was negligible compared to the work done, some indication of this was needed for the award of more than two marks. Another error was to use the kinematic (*suvat*) equations. These are only valid for motion in one direction with a constant acceleration.

In questions 03.4 and 03.5 examiners expected to see a quantitative analysis using the data provided. Vague answers that simply stated "*the launch speed would be faster*" did not gain credit. The best answers indicated clearly how much faster the launch speed would become. Unsurprisingly, more students were able to obtain full marks for 03.4 than for 03.5. Many students did not realise that there would be four times the work done in 03.5, as both B and I would double.

Some answers referred to issues of back emf in this question. Although this would be an issue in a practical situation, the question states that the current is kept constant and no reference is made to how this is achieved.

QUESTION 04

This question continued the trends seen in other questions on this paper. The straightforward calculation in 04.1 was successfully completed by the majority of students. Some students only gained one mark if they subtracted the radii from the separation. Another error was failing to square the separation in their calculation, even when the square was written in the equation.

There were many possible pathways through 04.2, but the majority of students were unable to make any progress with it. The best answers set out their calculations clearly, following a logical sequence. Some students did not realise that, in a radial field, the equation for work done, $W = Fd$, was not appropriate.

04.3 was another question where unclear answers cost marks: "*towards the negative signs*" covered a wide range of directions and was not credited, for example.

In 04.4, the calculation was completed correctly by most students. The mark scheme was broken down into clear steps that allowed almost all students to gain some credit.

The calculation in 04.5 proved to be more challenging, perhaps due to the context rather than difficulties with the physics.

Most students were able to calculate the energy in 04.6, with those who could not complete 04.5 making use of the "show that" value for the capacitance. The "show that" value is usually provided to allow

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students to make progress in subsequent parts. Examiners also expect it to be used if the answer calculated by the student is not consistent with the “show that” value.

QUESTION 05

The first two parts of this question were relatively straightforward calculations that were completed correctly by most students. Students could still gain full credit in 05.2 when they used an incorrect value for the acceleration from 05.1.

05.3 proved to be slightly more challenging and it discriminated well. This is another example of students gaining partial credit provided the answer was set out clearly so the examiner could see what the student was attempting to do.

A common difficulty with question 05.4 was treating the sign of the gravitational potential. The idea of the total energy of an object in orbit is an important one, and familiarity with it would have helped these students.

The best answers to question 05.5 showed an understanding of the relationship between centripetal acceleration and field strength. Some answers failed to get credit because they implied that the gravitational force was greater because the mass of the whole Moon increased, rather than viewing it as a localized event. Some students successfully argued in terms of the centre of mass of the Moon being closer to the orbiter, and therefore the gravitational force being bigger.

QUESTION 06

To answer this question well students needed to demonstrate a good understanding of electromagnetic induction and express it clearly. The lack of a calculation probably suppressed the marks significantly.

In 06.1 some idea of what is meant by the rate of change of flux linkage was expected, rather than just the mention of Faraday’s law. Some students stated that there was an increase in the rate of change of flux linkage. Whilst this was correct initially for this context, it did not explain why the emf was induced. Answers that referred to induced current rarely scored well.

The other parts to question 6 were also poorly answered. In order to obtain marks in questions like these at A-level, students need to demonstrate a good understanding of the physical principles involved and apply them to the particular context. The simple mention of relevant laws and describing outcomes in general terms is not rewarded.

SECTION B

All the multiple-choice questions except two were answered incorrectly by more than half of the students. Question 9, on the acceleration of a particle in a magnetic field, was the most accessible question, with questions 14, on field lines, and 15, on dielectric behavior, also scoring highly.

The most demanding question was 16. Most students chose option A. This suggests that many students have not considered what gives rise to eddy currents in a transformer core. The correct answer was C. Although the correct answer was the most popular in question 11, many students were also tempted by the other three options. Perhaps issues arose about the idea of an “*average emf*”.

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