OXFORD
INTERNATIONAL
AQA EXAMINATIONS

# INTERNATIONAL A-LEVEL PHYSICS

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

June 2022

# REPORT ON EXAMINATION: INTERNATIONAL A-LEVEL PHYSICS 9630 PH03 – FIELDS AND THEIR CONSEQUENCES – JUNE 2022

This paper had a similar demand to those of previous series with a similar mean and standard deviation.

As in most previous series, students performed better in the multiple-choice section than in the written section. In Section A, students performed best in one- and two-step calculation questions (such as 01.5, 02.3, 03.3), and in one of the algebraic derivations (06.2).

Students performed less well in questions about practical procedure (such as 01.1, 01.3) and definition questions (such as 03.1 and 05.1), which require carefully worded answers. Another particular area of weakness was answers to 'describe and explain' questions, particularly question 5. Skills that many students found difficult were the addition and resolution of vectors, in the context of electric fields (04.1) and a pendulum (10).

Students performed better in specification areas 3.6 (Circular and periodic motion), 3.9 (Exponential change) and 3.10 (Magnetic fields), but less well in 3.7 (Gravitational fields and satellites) and 3.8 (Electric fields and capacitance). Specifically, they answered poorly in areas relating to conservation of energy or charge in the context of fields and capacitors (questions 02.2, 02.4, 05.3, 05.5).

Some general principles that apply in every series:

- When a question asks for the definition of a quantity, the answer must be in terms of quantities, not units. When the question asks for the definition of a unit, the answer must be in terms of units, for example questions 03.1 and 05.1 in this paper.
- When an explanation- or description-type question is quantified then a quantified answer is expected, for example questions 05.2 and 05.4 in this paper.
- When a question requires data from a previous answer, the previous part is likely to be a 'show that…' question. Examiners expect students to use the 'show that' value as printed in the paper or to a greater number of significant figures (sf). There is a fuller explanation of this point in the report on questions 03.3 and 03.4.

## QUESTION 01

Questions 01.1 and 01.3 are about the practical use of an oscilloscope and were very poorly answered. Fewer than one-third of students scored any marks in each of these. In 01.3, a significant minority of students suggested that the peak emf should be found by calculation using the time period and magnetic field strength, rather than determined practically using the oscilloscope; this question had a significant number of non-attempts. Oscilloscope use was a marked area of weakness for this group of students.

Most were able to score one mark in 01.2, in the calculation part of the question. Generally they did not score marks requiring the practical skill of determining several periods and calculating an accurate average of them.

Questions 01.4 and 01.5, a one- and two-step calculation respectively, were much better answered with around half of the cohort scoring full marks in each.

## QUESTION 02

This question, about gravitational fields and satellites, also identified areas of weakness for this cohort. A recurring error was to confuse the gravitational potential energy and the total energy of the satellite.

02.1 is an algebraic derivation but was not as well answered as the other question of this type (06.2). Although very few left the answer space blank, some students tried to use $\Delta E_{\mathrm{p}} = mg\Delta h$ which is inappropriate in this context. Others failed to start from first principles (equating the gravitational force with centripetal force). A significant minority derived the kinetic energy ($E_k$) only, and then merely reversed the sign so that it matched the final solution, rather than adding the gravitational potential energy ($E_p$).

02.2 and 02.4 are explanation questions relating to the energy of the satellite and were very poorly answered, with only around a quarter scoring any marks in either. Many students clearly showed misconceptions about $E_p$. For example, in 02.4 many students stated that $E_k$ and $E_p$ must be '*balanced*', so that if one is increased then so must the other. Others stated that the total energy of the satellite must be constant, so that if $E_k$ is increased then the $E_p$ must decrease. Both of these suggestions are incorrect.

02.3, a one-step calculation, was well answered, with almost 60% of students scoring full marks.

02.5 is also a one-step calculation but was less well answered, with many students using the equation for $E_p$ rather than the total energy for the satellite, and earning no marks.

## QUESTION 03

This question, about exponential decay, as a whole was the best-answered question in section A. Students did especially well in the calculation parts.

03.1 asked for the definition of activity and was relatively poorly answered. A definition of a quantity must be in terms of other quantities, not in terms of units. In this case '*per second*' is incorrect, but '*per unit time*' is correct. (Cf question 05.1, which asks for the definition of a unit). We also required the word '*nuclei'*, because '*decay of atoms*' is a different physical process from nuclear decay.

03.2 was slightly less well answered: although most students understood that the 0.2 $min^{-1}$ value came from $\frac{1}{6}$, few were able clearly to relate this to the meaning of the decay constant. Many students implied that the decay constant is the probability of a particular nucleus decaying (or in this case one die showing a 6), but left out the time-dependence aspect of the decay constant (per unit time).

03.3 and 03.4 are calculations involving exponentials and natural logs and were very well answered, with around 80% of students scoring full marks in each. Both question parts require data from a previous answer (specifically the decay constant found in 03.2). Examiners only give full credit when a student uses the 'show that…' value from the question whether to the number of sf quoted (in this case 0.2 $min^{-1}$), or to the full number of sf (in this case 0.167 $min^{-1}$). In this case, a significant minority of students determined the decay constant to be an incorrect 0.28 $min^{-1}$. This does not round to the 'show that' answer and is penalised when it is used in subsequent calculations.

03.5 was answered correctly by only 20% of students; some left the answer space blank. A common misconception was that the probability itself, or the decay constant, varies with each dice roll. In fact, while the outcome varies with the initial number of dice, the probability does not.

## QUESTION 04

This cohort found question 4 the second-hardest overall in section A.

04.1 is a multi-step calculation requiring addition of vectors and was poorly answered. Most students scored only one mark, by using Pythagoras correctly to determine the distance. The majority were unable to add the electric field vectors correctly after resolving them vertically.

 

04.2, a graph sketch, was also poorly answered with only around 10% of students scoring full marks. This required a graphical addition of potentials. Although almost all students showed that the curve would have a $\frac{1}{r}$-shaped curve, some drew either the electric field graph or the potential graph for one charge.

04.3 also poorly answered. Many scored the first marking point, and only 5 % of students explained correctly that the two charges both repel the mass, and that the nearer one always repels more.

04.4 was also poorly answered, with hardly any students scoring full marks. Examiners saw the following misconceptions: writing 'gravitational potential energy' instead of 'electric potential energy' (EPE); stating that the EPE was reduced to zero in the centre (confusing EPE with electric field strength perhaps). Many answers were too brief to score the second marking point.

04.5 was intended to challenge the best students. Although many students showed an understanding of simple harmonic motion, many did not realise that this context does not fulfil the criteria. A majority of students simply answered '*yes*'.

## QUESTION 05

This cohort found question 5 the hardest overall in section A.

05.1 asks for the definition of a unit. Only 20% scored this mark, even though most showed some understanding of capacitance. Capacitance is defined as the charge stored per unit volt; however, this question is asking for the meaning of 37 mF, so each unit in the definition must be given (ie 37 millicoulombs per volt). Many students mixed and matched units and quantities in their definition.

05.2 and 05.4 both asked for a description and explanation couched in quantitative terms. In both, very many students lost marks by providing only qualitative answers (for example '*the charge increases*' instead of '*the charge doubles*'). However, most students presented equations as part of their explanations. In 05.4, the misconception that the energy stored, or the voltage, might remain constant was commonly seen. Finally, a significant minority of students misunderstood that an 'open switch' means a switch that is OFF, and a 'closed switch' is ON (allowing charge to flow).

This cohort found 05.3 very difficult and only a handful of students scored the mark. Several misunderstandings were seen, including the suggestion that charge is '*provided*' by the cell; and the implication that charge can be converted from some other quantity such as voltage.

05.5 was similarly poorly answered with very few scoring the mark. Only a minority of students understood that the energy stored increased, and fewer still identified how this was done.

## QUESTION 06

This question was relatively well answered overall.

06.1 was perhaps surprisingly the least well answered part of the question, with only around 1 in 6 students scoring the mark. The very common misconception was that the movement of the charged particle must be perpendicular to the field.

06.2 was very well answered, with over two-thirds scoring full marks. In a relatively straightforward algebraic derivation such as this, examiners only award the mark for a convincing re-arrangement. To give an example, when a student writes, on one line: $F = Bqv = \frac{mv^2}{r}$, and then in the same line crosses out the first $v$ and the $^2$, this leaves $F = Bq$ which is incorrect. Examiners saw responses such as this. In calculation questions examiners may be less strict with small algebraic errors such as this, but here the quality of the algebraic derivation is being examined and students must give each step in full without shortcuts.

06.3 was well answered with around one-third scoring at least two marks. Generally, the mark that students missed was the first: that the particle loses kinetic energy as it travels.

06.4 was fairly well answered, with the majority of students scoring at least one or two marks. One common pitfall was students failing to show evidence of the direct measurement on the diagram (in a similar way to that expected in a gradient determination on a graph). Students often gave their answer to too many sf, which is inappropriate for the precision of the method used.

06.5 was well answered with around one-third scoring at least two marks. Some of the responses required more detail to gain the marks. For example, students lost marks for writing simply '*the particles have opposite charge*' without clarifying which two out of the three were meant. A significant minority also wrote '*the particles have opposite charge so they repel*', showing a complete misunderstanding of the reason why the two charged particles move apart.

## SECTION B

The best-answered questions were:

- 9 and 11, both about proportional analysis;
- 17, unit manipulation;
- 19, straightforward algebraic manipulation of two force equations;
- 21, an application of Lenz's Law.

The worst-answered questions were:

- 7, a practical question; a popular distractor was B, which is a dependent variable but not directly measurable.
- 10, an algebraic derivation of forces in a pendulum context; a popular distractor was B, from an incorrect manipulation of vectors.
- 15 and 16, both about capacitor discharge; in both cases, the distractors chosen showed that students misunderstood how resistance affects the time constant.
- 20, about magnetic induction: a popular distractor was B, because some students did not realise that the emfs induced on opposite sides of the coil cancel each other out.

There were no questions where a distractor was more popular than the correct answer.

 

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