Examiners' Report
Principal Examiner Feedback

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Pearson Edexcel International Advanced Level

Physics (WPH04)

Unit 4: Physics on the Move

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General Introduction

The assessment structure of Unit 4, Physics on the Move is the same as that of Units 1, 2 and 5, consisting of Section A with ten multiple choice questions, and Section B with a number of short answer questions followed by some longer, structured questions based on contexts of varying familiarity.

This was a relatively straightforward paper that allowed learners of all abilities to demonstrate their knowledge and understanding of Physics by applying them to a range of contexts with differing levels of familiarity.

Learners at the lower end of the range could complete calculations involving simple substitution and limited rearrangement, including structured series of calculations, but could not always tackle calculations involving several steps or other complications, such as taking into account the number of wires in a coil or being told the charge lost from a capacitor rather than the charge remaining. They also knew some significant points in explanations linked to standard situations, such as cyclotrons and electromagnetic induction, but missed important details and did not always set out their ideas in a logical sequence, sometimes just quoting as many key points as they could remember without particular reference to the context.

Steady improvement was demonstrated in all of these areas through the range of increasing ability and at the higher end all calculations were completed faultlessly and most points were included in ordered explanations of the situations in the questions.

Section A –Multiple Choice

The multiple choice questions discriminated well, with performance improving with across the ability range for all items. Learners around the E grade boundary typically scored about 6 or 7 and A grade learners usually got 9 or more correct.
The percentages with correct responses for the whole cohort are shown in the table.

Question	Percentage of correct responses
1	86
2	83
3	86
4	76
5	65
6	92
7	72
8	78
9	57
10	86

More details on the rationale behind the incorrect answers for each multiple choice question can be found in the published mark scheme.

Section B

Question 11:

(a) Over two thirds of learners added the charges correctly, although a noticeable minority failed to make any response. Some learners responded by adding a proton number and an atomic mass number, which was not appropriate for this sort of equation, despite being told to show the charges.

(b) A majority scored at least 2 marks for this question. The most commonly awarded mark was for the three quark structure of protons and neutrons, frequently quoted as uud and udd respectively, although they are not required to recall the precise quark composition of particles. Learners did not always identify these as baryons, or sometimes only said they were hadrons, and more reliably identified electrons as leptons. The most frequent missing marking point was for a correct reference to fundamental particles, electrons being identified as fundamental much more often than baryons being described as not. A surprising proportion applied a quark structure, either single of quark-antiquark, to electrons.

Question 12:

The majority of learners completed this satisfactorily to gain 4 marks. Some learners did not include a reference to $F_E = Eq$ and started with $F_E = Vq/d$. These learners were awarded 3 marks for because they had not fully answered in terms of fields but had started with a derived formula. Even with the lowest scores, $F_B = Bqv$ was rarely omitted. Some learners did not clearly differentiate between v and V in their writing.

Question 13:

13 This question was answered very well overall. Over half of the learners scored at least 6 marks out of 7 for the whole of question 13, with a third scoring full marks.

(a) Although resolving perpendicular to the initial direction of the alpha particle was simpler and involved much less calculation, nearly all learners chose to resolve along its initial direction.
Where learners went wrong, it was most commonly by not taking any account of the angles. This led learners to an answer of about 5.4×10^6 m s^{-1} which was not far from the 'show that' value of 5.2×10^6 m s^{-1}, so many did not realise that they had made a mistake. Another error was not taking account of the alpha particle's component of momentum being negative.

(b) Learners generally had little difficulty with this part, but some errors were seen at a steady rate during marking. There was the usual frequency of those omitting to square velocity, either at the substitution or calculation stage. Some learners thought the test for an elastic collision was conservation of momentum rather than kinetic energy and others included sin or cos of the angles still as in part (a). Of those who completed the calculations, some were not awarded the final mark because they did not make a statement referring to the kinetic energy, just making a statement about whether or not it was elastic. Some learners taking their answers to a greater number of significant figures than were justified by the data decided that the collision was not elastic because the answers did not match exactly. They were still given the mark if they made their reason clear. Most judged that a slight difference in their calculated answers was acceptable.

Question 14:

(a) Approaching half of learners scored full marks, but many did not get any marks. Some learners adopting the correct method did not use two electron masses and a few used the mass of a proton instead. A significant cause for being awarded no marks was arriving at a numerically correct answer by using completely incorrect physics, in this case explicitly starting with $\lambda = h/p$ and calculating momentum using $p = 2m_ec$ – in other words, the mass of two electrons multiplied by the speed of light – so $\lambda = h/2m_ec$. Learners surely know that a particle with mass cannot travel at the speed of light, so this cannot be correct physics. Occasionally learners went through all the steps in the correct order algebraically before substitution, saying $\Delta E = c^2 \times 2m_e$ and $\lambda = hc/E$ so $\lambda = h/2m_ec$ but this has been shown using only correct physics and could be awarded the marks.

(b) About half got this correct, with many others discussing what should happen rather than why the proposal in the question should not.

(c) Only about a third scored on this question, usually for the idea that the positron would annihilate on meeting an electron. Very few discussed any other fate for the electron because a great many assumed that the positron and the electron created would meet again and annihilate. This was despite the other extremely common assumption, that the particles would follow spiral paths, meaning that they would not meet. The assumption of a spiral path was probably because they have seen many examples of similar events in a magnetic field, but no magnetic field was mentioned in this question.

Question 15:

(a)(i) Nearly all learners labelled weight and tension, but a significant minority did not get both marks because they added a third force, usually centripetal force, which is the resultant of the two forces and should not be on the free-body force diagram. Some learners left significant gaps between the force arrows and the object and did not gain credit, although we were not insisting on the arrows starting exactly at the centre of mass.

(a)(ii) The great majority scored both marks straightforwardly. Some learners only calculated the angular velocity and some had problems with the period of the rotation, using 36 revolutions divided by 60 seconds as the time. Occasionally learners gave the answer as a multiple of pi, e.g. $12\pi/25$, which is what a calculator display might show at first, but fractional answers are not acceptable for this sort of calculation (an exception would be phase difference with waves).

(a)(iii) Over half of the learners completed this successfully for full marks. Some reversed the components and were unable to procced towards the solution. A surprising number identified the components correctly and divided them but got an 'upside-down' final formula.
Learners who attempted to explain without the use of formulae were not able to gain marks.

(b) Although many had some sense of the required measurements, the majority did not give answers in sufficient detail to be awarded marks. For example. A large proportion suggested measuring speed and radius, but without any suggestion as to how this could be done. Of these, a great many suggested plotting a graph and using the gradient to determine the value of tanθ. This made no sense because once speed and radius have been changed to allow points to be taken for a graph there is no reason to think that the angle will be constant. Some suggested photography or video, but rarely mentioned how to ensure that the maximum angle from the perspective of the camera was the angle measured. A common good suggestion was determining two out of the length of the string, the diameter of the rotation or the height of the point of suspension above the plane of rotation, although the use of a ruler was frequently omitted, and using trigonometry. A disappointing number of learners, however, used tan when they should have used sin and vice versa, especially surprising when the diagram including the angle was plainly visible on the facing page.

Question 16:

(a) While the majority of learners displayed an outline understanding of the cyclotron, a lack of significant details in many of the points they made meant that only about half scored 3 or more marks. Such missing details included saying that the acceleration by the electric field takes place between the dees, saying that the applied magnetic field is perpendicular to the direction of the velocity of the protons, and being clear about exactly when the applied potential difference is reversed. Learners also failed to be awarded the first mark because they answered only in terms of protons being attracted or repelled by one side or the other on the gap, while others stated that the electric field accelerated the protons while they were in the dees.

(b) Just over half of the learners completed most of this sequence of calculations correctly, scoring 7 marks out of 8, with a quarter getting full marks. A few went awry with the use of MeV or used the mass of an electron in part (i) and some used the mass of a proton as the charge in part (ii), but learners were generally relatively successful in these parts.
The most common mark not achieved by learners was the final mark in part (iii) because they either failed to include a clear comparison between the calculated wavelength and the diameter of the nucleus, or they made the wrong conclusion, saying that the wavelength is not suitable. Some learners completed the calculation in part (iii) but failed to include a unit and so were not awarded the second mark. Similarly to question 14a, there was a method resulting in a correct numerical answer using incorrect physics. This time, a smaller proportion of learners treated the proton as a photon and used $\lambda = hc/E$ instead of $\lambda = h/p$.

Question 17:

(a)(i) About a third of the learners made a suitable suggestion to gain a mark. Many of the rest simply stated that there was no charge inside the sphere or that there was no force – but not what it was that was experiencing no force. Others just repeated 'no field lines'.

(a)(ii) The marks were fairly evenly spread between 0, 1 and 2, so about two thirds got at least 1 mark. Most appreciated that the field strength decreased with distance, but a variety of errors or lack of precision limited their marks. Some drew a concave curve starting at 0, others drew something more like the variation of the Earth's gravitational field strength, including the slight increase just after R_0. Some did not touch the dotted line when they should have had a definite start and others had a definite meeting with the distance axis when they should not have touched, but these learners often gained a mark because no field was shown at a distance less than the radius as no marking was taken to indicate a zero value, even if no horizontal line along the x-axis could be seen.

(b) Over half of the learners got at least 4 marks out of 6 for this section, with part (i) scoring more highly than part (ii).

(b)(i) Most could complete this, but some calculated *C* and gave that as their final answer, others used the given value of charge as *C* and used that and the radius to calculate a value of ε, which they gave as their answer.

(b)(ii) Most were able to use the decay equation for charge, but a very large proportion used took *Q* to be $0.7 \times Q_0$ rather than $0.3 \times Q_0$.

Question 18:

(a) About three quarters of the learners quoted Fleming's left hand rule, but only about half of them described the direction correctly. Some stated out of the page or into the page, but didn't say whether they meant at A or at B, so they could not be credited.

(b) Nearly all got credit for using $F = BIl$, but only about a third of learners completed the calculation successfully, most of the rest neglecting to account for 32 turns.

(c)(i) A good majority scored 2 marks out of 3 for describing the induction of an e.m.f., although some did not because they described the coil cutting its own field lines, but only about one in five scored all 3 marks. Learners often failed to refer to Lenz's law in their answers, or invoked other mechanisms.

(c)(ii) Only about half scored on this question, and many had a good idea but failed to demonstrate their understanding sufficiently well to gain many marks. The most common mark was for variations of the first mark, $\varphi = BA$. The chief problem was in defining the area since many just stated that it was l^2 without making it clear where the second *l* was from. In the better responses, learners labelled the distance travelled by the wire on the diagram or stated it, often as *vt*.

(c)(iii) A little under half gained a mark in this part, with many errors evident throughout the question and very few scoring all 3 marks. Errors included using an incorrect value for length, not halving the width to obtain the radius, effectively using 9 seconds instead of 9 per second and not using 32 turns.
Some used $\varepsilon = BAN/t$ which does not give the maximum e.m.f.

(c)(iv) Full mark answers were rare, with about a third scoring one mark, usually for a statement that the rate of change of flux varies without a suitable reason. Many assumed that the speed of rotation varied. Some said that the angle of the wire to the field varied, but it was always perpendicular – they may have meant the angle of the wire's velocity, but this was no expressed clearly.

(c)(d) Again, about a third scored one mark, usually for reference to a data logger but not the sensor. Most learners failed to appreciate the rate at which the current must be changing with 9 rotations per second. That means 18 reversals in direction each second. Using an ammeter and stopwatch is impossible, not only because of human reaction time but because a standard ammeter could not display the correct current with that rate of change. That is why videoing would not work either – the meter itself could not keep up.

Summary

Based on their performance on this paper, learners are offered the following advice:

- Check that quantitative answers represent sensible values and to go back over calculations when they do not.
- Learn standard descriptions of physical processes, such as electromagnetic induction, and be able apply them with sufficient detail to specific situations, identifying the parts of the general explanation required to answer the particular question.
- With wave-particle duality, be sure whether you are calculating wave or particle properties.
- Physical quantities have a magnitude and a unit and both must be given in answers to numerical questions.
- When substituting in an equation with a power term, e.g. v^2, don't suddenly miss off the index when substituting or forget it in the calculation.
- When working with components it can help to sketch the relevant triangles rather than try to apply them from memory.
- Where you are asked to make a judgement or come to a conclusion by command words such as 'determine whether', you must make a clear statement, including any values being compared.

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