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Examiners' Report
Principal Examiner Feedback

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Pearson Edexcel International Advanced Level
In Physics (WPH04)
Paper 01 Physics on the Move

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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 the first October series sitting of the unit.

This paper allowed candidates of all abilities to demonstrate their knowledge and understanding of Physics by applying them to a range of contexts with differing levels of familiarity.
Candidates 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 two jet engines, accounting for two particles given the data for one or correctly identifying when to apply conservation of energy as opposed to conservation of energy for a novel situation. They also knew some significant points in explanations linked to standard situations, such as linacs 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 from the mark schemes for previous papers without particular reference to the specific 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
The multiple choice questions discriminated well, with performance improving with across the ability range for all items. Candidates around the E grade boundary typically scored about 7 and A grade candidates 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	89
2	31
3	86
4	94
5	86
6	93
7	48
8	94
9	75
10	62

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

Section B

11 Students generally applied the concept of change in momentum to the question, usually allied with impulse, to calculate a change in speed of the air. Students frequently, however, did not take into account two engines and some did not apply the speed of the aeroplane to determine the relative speed.
Some candidates did not apply the time of 60 seconds correctly, either omitting it or applying it twice. Others used force and mass to determine a value of acceleration which was then used in $v = u + at$ with a time of 60 seconds, as if the air took this time to pass through the engine.

12 (a) Most students gained credit for identifying the three quark structure of protons and neutrons, although some simply quoted udd or uud without mention of the word 'quark' and failed to gain credit. Candidates usually mentioned baryons or leptons correctly in context, but not always both. Some said that a helium atom contained 2 leptons and 12 quarks without being more specific.
The ambiguous phrase 'baryons are made of 3 quarks or anti-quarks', which could include a mixture of quarks and anti-quarks, was sometimes seen instead of 'baryons are made of 3 quarks or 3 anti-quarks'.

12 (b) The great majority of students applied $\Delta E = c^2 \Delta m$ but a significant minority did not apply it for the mass of two particles and a small minority did not square c, even after writing c^2.

13 (a) About half of the entry completed the question correctly for full marks, although many of the remainder only gained credit calculating r using the first method on the mark scheme or for the correct calculation of force using $F = Bqv$ using the second method.
Some completely incorrect methods were seen which seemed to be based on finding formulae from the list at the end of the paper that appeared to contain the correct letters, even though the letters represented different quantities and the formula were for unrelated physics. Some calculated F correctly but then used $E = F/Q$, although there is no electric field in the question, and then $E = hf$, although this is an entirely different E, being photon energy. Others used mv to calculate p, but then used $\lambda = h/p$ for the de Broglie wavelength and then $v = f\lambda$, with $v = 400 \text{ km s}^{-1}$, to calculate something entirely unrelated to circular motion or any other relevant physics.
Candidates sometimes used proton mass instead of electron mass.

13 (b) Slightly under half of the entry scored on this question, and not usually more than two marks. The marks most frequently awarded were for stating that the force on the electrons is into the page or that the force perpendicular to the electron path caused circular motion, but many gave answers that just suggested these without the required detail to be awarded a mark. For example, the magnetic field perpendicular to the motion caused circular motion, without linking to the force produced, or just stating that there is a force perpendicular to the motion without stating that it is horizontal or into the page.
A correct explanation for the downwards motion was rarely given, incorrect suggestions being that it was due to weight acting downwards. Some students interpreted spiral in the sense of particle tracks seen in questions in previous papers and gave answers seen in previous mark schemes, such as a loss of energy and therefore momentum, referring to $r = p/BQ$.

14 While the physics and mathematics in this question were not beyond their ability, many candidates at the lower end of the range approached 14 (a) using conservation of momentum followed by 14 (b) using conservation of energy, the reverse of the correct approach, whereas those candidates applying the principles in the correct order were able to work through the whole question successfully to be awarded 7 or 8 marks. Throughout the question some students incorrectly added the mass of the pellet to the mass given in the question for (block plus pellet), suggesting a more careful reading of the information.
14 (a) Candidates approaching this using initial kinetic energy of (block plus pellet) = final gravitational energy of (block plus pellet) had few difficulties. Some candidates, however, applied the equation for uniform acceleration $v^2 = u^2 + 2as$ and gained no credit because this is not a situation involving uniform acceleration in the direction of motion.

14 (b) Again, candidates approaching this with the correct principle, conservation of momentum, had few difficulties and most made a clear statement allowing a determination of the legality of the airgun.

14 (c) Whatever method had been adopted earlier, most candidates were able to apply their earlier answers to calculate the initial kinetic energy of the pellet and many of those made a relevant comparison to determine whether the interaction was elastic. Simply stating that energy was not conserved without values of kinetic energy was not sufficient for the second mark.

15 (a) This question also included assessment for the quality of written communication. The great majority of the entry were awarded marks for this question, with well over half scoring at least 2 out of 3, usually for identifying an induced e.m.f. and a change in magnetic flux linkage, in common with many questions on previous papers about situations involving electromagnetic induction. Relatively few, however, identified the cause of the change in magnetic flux linkage correctly or in sufficient detail. For example, some merely stated that the current magnetised the coil without reference to a magnetic field. A substantial minority referred to answers from previous questions involving two coils and answered in terms of alternating current, ignoring features of this question such as the battery in the diagram and the spark being caused when the switch was opened, limiting themselves to the third mark. Some candidates were not awarded the third mark because they just referred to a potential difference being produced, as in the question, or introduced only one of the terms 'e.m.f' or 'induced'. Some candidates appeared to be thinking of previous mark schemes when they referred to a current flowing because there was a complete circuit.

15 (b) The great majority completed this straightforward calculation successfully. Occasional errors included using 110 V rather than 110 000 V, rearranging the formula incorrectly to multiply by 110 kV rather than dividing, and omitting the unit in the final answer.

15 (c) (i) The majority of the entry gained credit for this question, but a significant segment did so only for using the formula $E = V/d$ because they did not use it for a relevant comparison. Some pointed out that both quantities went up in equal steps, thinking this was evidence of uniformity rather than seeing that it was not because taking the next step backwards would not lead both to zero, i.e. a linear but not

proportional relationship. Comparisons of *V/d* between rows of the table were much more common than comparisons with the maximum electric field strength before sparking.

15 (c) (ii) Candidates only occasionally got the direction of the field, from plus to minus, incorrect and the majority also drew a reasonably shaped field. Some candidates drew a field as if for parallel plates.

16 (a) Most responses were awarded at least one mark, usually for identifying interactions with air molecules, although a number were seen that referred to interactions with ‘other particles in the air’, or even just ‘with air’, and did not gain credit. About a third of these went on to identify a relevant consequence to the outcome of the experiment in sufficient detail, a typical insufficient response being that the alpha particles would lose kinetic energy, or just that it would affect the results of the experiment.

16 (b) Relatively few candidates made responses sufficient to gain credit, with many just linking observations and conclusions as in previous questions on alpha scattering, often repeating ‘concentration of charge in a central nucleus’ from the question without elaboration, or even that ‘the atom is mostly empty space’. They rarely made the explanatory link between the evidence and the conclusion.

16 (c) This question also included assessment for the quality of written communication. This was answered well overall, with the great majority gaining one or more marks and a fifth gaining full marks. While a few linked the answer to an increase in the mass or size of the nucleus, most set out their answers along the lines of the mark scheme answer, but sometimes missing any reference to charge, and therefore not being awarded the second and third marks.

16 (d) Students adopted a range of approaches to this question, with roughly two thirds being rewarded for their work. The most common method after that in the mark scheme was to calculate the force using Coulomb’s law and also by working ‘backward’ from the radius and comparing the results.
Overall, the most commonly awarded marks were for the Coulomb force and for the circumference of the orbit. A few candidates did most of the work correctly but failed to make the final comparison.

17 (a) This question also included assessment for the quality of written communication. This was relatively straightforward and about three quarters of the entry gained credit for their responses. The most common omission was that of the final stage in the process. Some students got the switches mixed up in their responses and some introduced the use of a stop watch, misunderstanding the function of the circuit entirely.

17 (b) (i) A majority completed this correctly. Some were only awarded the first mark because they did not add the two resistance values in the calculation of the time constant and some got no further than the time constant. Some students adopted an approach assuming discharge with constant current, as seen in a previous paper, using $V = IR$ and $Q = It$. For some reason, a number of candidates used an initial p.d. of 7.0 V.

17 (b) (ii) The general shape of the graph was straightforward for most candidates, with the most common errors being no intercept on the y-axis or having an intercept on the x-axis.

17 (b) (iii) Few candidates gained more than two marks for this question, the marks often being awarded for increasing the initial p.d. or increasing the resistance and/or capacitance, but not necessarily with correct reasons in support. Reference to a steeper gradient was also seen fairly frequently. Many candidates did not attempt to answer the question on the paper in terms of changes to the circuit but gave answers to previous questions on capacitor discharge in terms of using a data logger and the difficulty of making simultaneous readings, although only one reading, final p.d., was required.

18 (a) Over half of the entry gained credit for this question, with a third being awarded both marks. While apparently straightforward, atomic numbers and mass numbers were reversed for the neutron, the atomic and mass numbers for alpha particles were often used and extra particles, such as neutrinos, were added where the number of neutrons was required.

18 (b) (i) While candidates showed recognition of the linac, many did not include sufficient detail or did not respond to the question about the particular aspects required, i.e. how the protons are accelerated, so that relatively few gained more than two marks. For example, many referred to the later stages when particles approach the speed of light and the drift tubes are of constant length.
Candidates would often state that protons were repelled from one tube and attracted to the next, but did not refer to the part played by the opposite polarity of the tubes even though they often referred to polarity reversing. It was often not clear that polarity switched when protons were in the drift tubes, ambiguous answers suggesting that it happened just after they left the tubes and were in the gap. There were an unaccountable number of references to acceleration 'between the gaps', rather than 'between the tubes'.
18 (b) (ii) This was answered well overall, with the great majority gaining credit for at least applying the correct formulae to calculate the proton speed and nearly half being awarded at least 4 marks out of 5, the fifth most often not awarded because of a missing factor of 2 because it is only half a cycle between adjacent gaps.
Candidates sometimes used electron mass instead of proton mass. Some answers did not show the use of square root in the calculation of speed and some did not use 10^6 for the M in MeV.
18 (b) (iii) About a fifth of candidates gained one or more marks on this question, most commonly for stating that the time spent in the drift tubes is shorter. Answers referring to greater obtainable speeds or shorter lengths often lacked the detail required to link these with the same length of linac or the same final speed respectively.

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

- While past paper mark schemes can be useful revision aids, questions will not be identical so quoting them directly is unlikely to answer the particular question.

Be sure to answer the question on the paper and not the question from a previous paper.

- 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.
- 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. r^2, do not omit the index when substituting or forget it in the calculation.
- When using the list of formulae provided, be sure to learn the correct meaning of the symbols in a given formula, not confusing similar symbols, such as *v* for velocity with *V* for potential difference or E for photon energy with E for electric field strength.
- Be sure to know the standard SI prefixes and be able to apply the correct power of ten

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