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Examiners' Report
Principal Examiner Feedback

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Pearson Edexcel International Advanced Level In Physics (WPH14) Paper 01 Further Mechanics, Fields and Particles

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Introduction

The assessment structure of Unit 4: Further Mechanics, Fields and Particles 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 second 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 identifying the correct trigonometrical function to apply with a given angle. They also knew some significant points in explanations linked to standard situations, such as standing waves 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, with most points 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.

The percentages with correct responses for the whole cohort are shown in the table.

Question	Percentage of correct responses
1	76
2	57
3	63
4	41
5	70
6	76
7	55
8	57
9	93
10	30

Section B

Question 11

The majority of students recognised that the situation required the calculation of the force on a wire in a magnetic field, but many of them misapplied the formula $F = BIl\sin\theta$ and used the angle in the question directly substituted into it. The angle θ in the formula refers to the angle between the wire and the magnetic field, but in this situation the wire and magnetic field were perpendicular so the value of $\sin\theta$ was 1. The angle 20° was the angle between the plane of the coil and the magnetic field and was required in the moments calculation, where they should have used cos 20° or sin 70°.

Students also sometimes used the width instead of the width in the force calculation and the length instead of the width in the moments calculation, and others misapplied the factor of 2.

Question 12

(a) About half of the students correctly stated 'annihilation' and a wide variety of incorrect but recognisable spellings were seen. The most common incorrect response was 'pair production', and others included 'photoectric effect' and 'beta decay'.

(b) A good proportion of students were able to apply the required calculations to arrive at a value of wavelength, although some misapplied a factor of 2. A number of students arrived at a numerically correct answer through incorrect physics, attempting to apply the de Broglie wave equation $\lambda = h/p$ where they calculated momentum, presumably intending ot to be for a gamma photon, using mass of an electron multiplied by the speed of light. This is incorrect in many ways, not least because photons have no rest mass and electrons cannot travel at the speed of light. The answer is numerically correct because $E = c^2m_e = hf$ and $f = c/\lambda$, so $c^2\,m_e = h\,c/\lambda$, so $\lambda = h/m_ec$, but this is by quite different reasoning to the incorrect de Broglie method.

Question 13

Despite demonstrating good knowledge of the particles in the standard model and their properties, scores were very low for this question because students usually only described the standard model and made no comparison at all to the Zweig model, as required by the command word 'Compare'. Some of those who did attempt a comparison dealt with only differences or only similarities, but both must be addressed in order for full marks to be obtained.

Question 14

(a) A majority of responses gained some credit for stating that few particles were deflected, although some only stated that most were not deflected which was not sufficient to imply 'few'. Some just said that most 'went through with little or no deviation', which was also insufficient to suggest that only a few were deflected.

Very few students linked this to proximity to the deflecting charge, often just stating the memorised phrase phrase from GCSE, ‘so the atom is mostly empty space’.

(b) Some students apparently did not understand the requirements of the question because they assumed that the central charge was positive and ignored the possibility of a negative charge. Relatively few responses were worthy of credit, and most marks were obtained with the aid of diagrams. Some students appeared to have an idea of the possibility of deflection towards the nucleus as well as away from it but failed to score because they didn’t label the charge of the nucleus or misidentified the charge of the alpha particle as negative.

(c) Converting the energy of the particle to joule presented few difficulties, but most students did not appreciate that they then needed to apply the formula for electrical potential. Some, perhaps confused by the symbol *E* in the formula, equated this to electrical field strength for a radial field. A large minority attempted to use work = force x distance, which they should have realised could not be suitable due to the force varying in a non-linear way in this situation.

Question 15

(a) The majority of students realised that they would need to use work = force x distance, but simply used the length of the lever multiplied by the maximum force, which happened to give an answer close to the ‘show that’ value. Few students calculated an average force or the length of the arc representing the distance moved in the direction of the force.

(b) (i) This question required students to demonstrate their ability to structure an answer logically, showing the links between related points, with up to two marks being awarded for this. The mark scheme shows the process of awarding marks for structure.

A large majority of students were able to state at least two of the indicative content points related to this process, most commonly for ‘e.m.f. induced’ and ‘Complete circuit, so current’, which have often appeared in similar mark schemes for the predecessor specification.

Only about a third gained credit for the structure of their answers, often because they had not made at least three of the indicative content points in sufficient detail to be able to link them appropriately. Students rarely addressed the function of the diode or identified what was happening in each coil explicitly and they lacked precision in their descriptions of the change in magnetic flux linkage.

(b) (ii) Those students who realised that they needed to use the graph to determine the rate of change of magnetic flux density were able to complete this question, usually drawing a tangent at a point of maximum gradient. Many others incorrectly used the maximum magnetic flux density from the graph divided by some fraction of the period, usually a quarter, and simply calculated *BAN/t*.

(c) All of the methods in the mark scheme for calculating the capacitance were seen, with the most frequent being substitution of values from two points and the next by calculating the initial p.d. divided by *e* in order to determine the time constant although some, having been told values of potential difference and resistance, determined a value of current that they incorrectly attempted to use for a calculation of charge.
Candidates using mark scheme methods for capacitance frequently went on to determine the correct answer for energy stored by the capacitor, but rarely achieved the final mark because they did not make an explicit comparison with the value of energy stored by the mechanical mouse trap.

Question 16

(a) A range of valid proofs were seen, but many failed to make any reference to the small angle approximation and the diagrams used were very often not vector diagrams for this situation, or even vector diagrams at all, rarely showing the change in velocity and often mixing lengths and velocities.

(b) The great majority of the candidates were able to calculate the force on a charged particle in an electric field and to calculate acceleration using force and mass, but only about a third included the gravitational force acting on the spider in their calculations, limiting themselves to 2 marks. Students using a free body force diagram before their calculations did not make this error.

(b) (i) Most candidates correctly completed the vector diagram, although a not infrequent error was to include a third, horizontal force which was actually the resultant of the two required forces.

(b) (ii) Students were far more likely to complete this section correctly than to score intermediate marks for an incomplete calculation. Some students equated weight with centripetal force rather than considering them as equal to components of tension.

(b) (iii) A majority of students focused on one of the replies and didn't comment on the other. It was quite common to see incorrect reasoning that the angle would decrease as a greater radius meant smaller centripetal force, which is incorrect as the angular velocity was stated to be kept constant in the question. Most responses lost credit by skipping over discussion of components of tension. Very few candidates mentioned that in order for circular motion there must be a horizontal force. A surprising number of candidates confused horizontal and vertical directions.

Question 17

(a) Most students were able to refer to the lack of charge or ionisation.

(b) (i) The majority completed the nuclear equation correctly, but a not uncommon answer was achieved by failing to consider two alpha particles.

(b) (ii) Rather than draw a closed vector triangle by the tip-to-tail method, most responses just copied the photograph with vector arrows and estimated a direction and length for the
vector for the lead ion. When triangles were drawn, they often lacked arrowheads and labels. The arrow for the lead ion was also often drawn the wrong way around, as if it were the resultant vector rather than opposing it.

(b) (iii) Many students attempted to use conservation of linear momentum without first resolving the momentum vector of one alpha particle. The few that did remember usually proceeded to follow the rest of the method correctly. For those who had previously drawn a correct momentum triangle, it was common to see use of the cosine rule, which was usually done correctly from memory.
Many candidates assumed symmetry in the paths of the two alpha particles relative to the path of the lead ion and assumed that both were at an angle of 30 degrees to it, despite the plain difference in their velocities and therefore their momenta. Very occasionally, students justified this as an approximation because the difference in velocities was relatively small.
The majority at least realised that this was a conservation of momentum problem, but a few tried to instead use conservation of kinetic energy. This often gave an answer much greater than the speed of light, which should have indicated an error or at least indicated that they should look again.

(c) It was not uncommon to see references to 'track A', or simlar, without any indication of which track on the page they meant. Very few candidates referred to the gap between the two tracks, although some still talked about the recoil direction. It was slightly more common for them to discuss which path was shorter, though they rarely related this to the lower speed or the loss of kinetic energy and often stated that the shorter track was for the second alpha. Hardly any spoke about the thickness of the tracks, and those who did usually drew the wrong conclusion from it.

Question 18

(a) About a quarter of the students didn't state 'thermionic emission'. About a third of those correctly naming the mechanism did not describe it as required by the question. They very often described instead the acceleration of the electrons as has been required for similar questions in previous examinations and would have been seen in previous mark schemes.
Those who did attempt the correct description sometimes talked about "excited" or "delocalised electrons", which are not the same thing, or about electrons leaving atoms rather than the bulk metal. They also often omitted to mention that the electrons themselves gain energy.

(b) (i) A majority of students successfully converted eV to joule straightforwardly, although some included a factor of ½ by attempting to use the equation for energy stored by a capacitor, which they presumably extracted uncritically from the formula sheet. Very few realised that 60 tubes meant only 59 accelerating regions between them. A similarly small number forgot to add the initial kinetic energy of the electrons, although this was a negligible quantity relative to the final energy.

(b) (ii) Nearly half of the students gained credit for stating in sufficient detail that, as the electrons approach the speed of light, there is no further appreciable increase in speed, but many who had an idea of this fell short by saying that electrons travelled at the speed of light, or even at speeds in excess of the speed of light, or only mentioned relativistic effects without being specific about the speed.
A small proportion completed the answer successfully, but many did not refer to the same time spent in the tubes or link it to distance = speed x time in sufficient detail.

(c) The great majority scored nothing for this very standard description that one would have expected to be very familiar, even though the question only asked how standing waves are formed and did not refer to this specific context.
Students often failed to mention waves travelling in opposite directions and sometimes used the incorrect term 'superimpose'. They often mentioned destructive or constructive interference but did not link it to phase difference – or they even tried to refer to path difference but had no reference point from which that difference would arise. 'Out of phase', which just means any phase relationship that is not 'in phase' was generally used in place of the more specific 'antiphase'. Amplitude was very rarely mentioned, so the most common way in which the third mark was obtained was by reference to nodes or antinodes linked to the correct interference.

(d) About half of the students were able to make progress with this question, starting with the determination of the electron energy in joule. Most who were able to calculate momentum from this were able to complete the question correctly. Some students attempted to use $r = mv/Bq$, but using the speed of light as v. Quite a few, seeing 270° in the question, assumed that an angle had to be included, although it was just intended to indicate a section of circular motion in the context of this machine.

Paper Summary

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

- Where you are asked to come to a conclusion by command words such as 'determine whether' or 'deduce whether' using numerical data, you must complete your calculations, then explicitly compare the relevant values and then make a clear statement in conclusion – 'Calculate, Compare, Conclude'.
- Show all steps and substitutions clearly in derivations.
- Check that quantitative answers represent sensible values and to go back over calculations when they do not, for example when a calculated speed is greater than the speed of light.
- Address all points specifically mentioned in questions, such as the inclusion of diagrams.
- Learn standard descriptions of physical processes, such as electromagnetic induction and standing waves, and be able apply them with sufficient detail to specific situations, identifying the parts of the general explanation required to answer the particular question.
- While past paper mark schemes can be useful revision aids, questions will not be identical so quoting them directly is unlikely to answer a particular question. Be sure to answer the question on the paper and not a question from a previous paper with a similar situation.
- When substituting in an equation with a power term, e.g. x^2, don't suddenly miss off the index when substituting or forget it in the calculation.

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