# Examiners' Report
# Principal Examiner Feedback

January 2024

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

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 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 short structured series of calculations, but could not always tackle calculations involving several steps or other complications, such as using radius when the diameter was provided in the data or correctly identifying particles to which the de Broglie equation should be applied. They also knew some significant points in explanations linked to standard situations, such as alpha scattering, cyclotrons and electromagnetic induction, and could generally set out their ideas in a logical sequence, but could not always identify which points were most relevant for a particular context, even when it was a familiar one. There was also a lack of specific detail in answers.

Steady improvement was demonstrated in all of these areas through the range of increasing ability. Candidates at the higher end of the range could faultlessly complete complex calculations including several stages without requiring structured questions. They were able to set out explanations with logical structures including the majority of points in the required detail.

**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 | 96 |
| 2 | 96 |
| 3 | 92 |
| 4 | 61 |
| 5 | 28 |
| 6 | 56 |
| 7 | 74 |
| 8 | 52 |
| 9 | 47 |
| 10 | 59 |

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

11 Nearly all students could apply the formula for energy stored and the majority achieved full marks for this question, but there were a number of common errors among the minority who did not. Some did not apply 20% and some applied it to the potential difference, which meant they were using 144% after squaring. Some students achieved the same effect by applying 20% to both capacitance and p.d. Some wrote the square in the formula and then omitted it when substituting values and some included in the substituted formula but not in their calculation.

12 Students usually demonstrated knowledge of particle tracks and their interpretation, but could not always explain the situation in sufficient detail to gain credit for their answers. In an explanation of a situation like that in this question, students need to state the observations they are using, but many did not do so with sufficient clarity. The most frequently made point was the absence of tracks for neutral particles, but this was often by implication rather than by an explicit statement. The absence of tracks after P was similar. The most successful answers identified the subsequent decays by annotating the diagram.

13 (a) Students had little difficulty in selecting the Coulomb law equation and substituting values to calculate a force, particularly as no rearrangement was required, but quite a few did not identify the charge of the helium nucleus as 2e, despite the statement in the question that both electrons had been lost. Many used the Coulomb law constant *k* appropriately rather than permittivity in their calculation, but some used the value of the Boltzmann constant, also *k*, instead. As with question 11, some wrote the square in the formula and then omitted it when substituting values and some included in the substituted formula but not in their calculation.
13 (b) Most students were able to tackle this part equally as well as part (a). Students tended to opt for direct calculation of the field strength rather than force/charge, but those doing so were more likely to omit the square.

14 This was well answered overall, with about a third of the cohort being awarded full marks, and half gaining at least 4 marks. Nearly all candidates showed that they understood what the question was asking and that they had a good idea of the type of responses that were needed and set out their answers in matched pairs of observations and conclusions.

The most consistently answered points related to the undeviated particles, although many candidates stated that they 'went through' rather than that they 'went straight through'. It was also not always stated that this applied to most particles. For the slightly deviated particles the description did not always include the idea of 'few' and some candidates regard anything up to 90 degrees as a small angle. For the final point, candidates frequently failed to convey the idea that a very small proportion were scattered through angles greater than 90 degrees, although '1 in 8000' was seen reasonably often. 'Few' was not sufficient here. There was a range of wording– reflected, bounced off, rebounded being fairly common.

15 Half of the entry scored full marks, but the rest were most likely to score 1 mark only for the de Broglie calculation. Students often did not use $E_k = p^2/2m$, using $\frac{1}{2} mv^2$ instead. Those doing so were more likely to encounter difficulty in completing the question as it introduced an extra step. Some candidates confused *V* for p.d. with *v* for velocity. Others used $W = \frac{1}{2} QV$, as for a capacitor, rather than $W = QV$. A substantial minority saw that they were given a wavelength misunderstood the situation, calculating the energy of the photon with this wavelength.

16 A third successfully completed this question correctly, often as a single calculation by applying *Blv*. Half of the entry got at least 3 marks. Where the score was 3 this was often when the speed or e.m.f had been calculated correctly but there was not an appropriate comparison with the value in the question or a specific conclusion.
It should be noted that students may use formulae such as *Blv* that are not on the specification to calculate answers, but 'use of' marks will not be awarded if the final answer is incorrect.

17 (a) There is a good overall understanding of this derivation with a majority gaining the final 3 marks for the algebra. Most attempted the method shown in the first example derivation on the mark scheme with a minority using similar triangles.A fair proportion using either method, however, did not show clearly that they were using the small angle approximation. Candidates usually included a diagram, but these often did not qualify for the vector diagram mark as they either had no arrows or had arrows that were not consistent with the change in velocity required.

17 (b) The majority were able to complete the calculations, although a fair few missed the final mark through lack of a numerical comparison of tensions as part of their conclusion. The most common error among the rest was to calculate the weight *W* in order to determine the lift force of 2*W* , but then not subtracting weight when completing the force calculation. In calculating the tension, the Pythagoras approach was much more common than the trigonometrical approach which involved an extra step.

18 (a) (i) Only a quarter were able to complete this successfully because most used treated this as a decay situation and substituted values from the graph into the decay equation directly without subtraction from 6.0 V. Some used the time constant approach, but usually with 37% rather than 63%. Many students took $V_0$ in their calculation to be 5.8 V rather than 6.0 V.

18 (a) (ii) A good majority scored at least 2 marks, with a third of the entry gaining full credit. The lines were of varying quality, the most common error being to intersect the time axis. Some students saw the command 'sketch' and drew their line without noting the following instruction to include the initial current value.

18 (b) Half of the entry gained credit here, fairly evenly divided between 1 and 3 marks. The rest frequently indicated that using resistors in parallel increased the resistance in the circuit. Those scoring 1 mark identified the decrease in resistance but usually went straight to the effect on the time without explaining in terms of current of time constant. As the question asked for an explanation of the change it could only be to increase or decrease, so the final answer needed to be fully supported in the explanation in order to gain the final mark.

19 (a) Only one in five completed this question fully because the majority adopted a de Broglie equation approach, taking the stated wavelength to be associated with the electron rather than the photon as stated in the question.

19 (b) The great majority completed the first two calculations correctly to obtain a radius value of 0.196 m, but they often did not know how to proceed further. Some just used this value to compare to 220 m directly. Quite a few went on to calculate the corresponding frequency, but didn't have another frequency with which to compare it. When applying the wave equation to calculate frequency from wavelength or vice versa, some candidates used

the electron speed rather than the speed of light. Some completed all calculations correctly but did not make the required explicit statement comparing values as part of their conclusion.

20 (a) About half gained full credit, with the majority of the rest being awarded one mark because the either omitted to include reference to ‘total’ momentum or they did not refer to external forces.

20 (b) (i) About half were able to complete the sequence of calculations to determine the required value. Some only used 2 significant figures rather than the extra one required for a ‘show that’ question. As the particles had the same mass, it was possible to cancel mass in the calculations, but students had to show that this was being done rather than just omit any reference to mass if they were to gain credit. Some candidates only gained a mark for calculating momentum and did not use components. Others did not set out their working clearly, so it was difficult to see where they were applying the principle of conservation of momentum.

20 (b) (ii) The great majority were able to apply the kinetic energy equation with the values provided and many calculated at least one kinetic energy, but relatively few gained full marks. There were arithmetic errors along the way, such as omitting the square term, but more common was omitting the required comparison of values as part of a conclusion.

21 (a) The great majority were awarded at least one mark and about half gained 2 marks. Even if they didn’t get all of the indicative context, answers were generally well structured.

The most common indicative content point made was referring to the production of a magnetic field with the next being that it was varying. Candidates often went on to make the next three general points in the standard electromagnetic induction explanation but they frequently did not gain credit because they didn’t indicate that this was happening in the kettle. Answers linked to the core were accepted, but many located this in the coil or had no location at all. Sufficient attention was rarely given to making the link between the resultant currents and the generation of heat. Some candidates attempted to apply Lenz’s law and others referred to thermionic emission.

21 (b) Only about a third of the entry were credited for this question. One problem candidates had was in distinguishing between thermal conduction and electrical conduction and often there was simply a restatement of the question. There were a lot of responses linking the observation to thermionic emission.

22 (a) (i) Half of the candidates identified the quark structure correctly. Some used down instead of strange and some did not give a meson structure, using three quarks, for example or not including an antiquark.
About a third explained the requirements for the structure with reference to quark-antiquark pair and the need for a strange particle or negative charge but many missed one of those points just re-described the structure.

22 (a) (ii)This was the best answered question in Section B, with three in four gaining full credit. The most common error was omitting the square for the speed of light at the substitution or calculation stage. Some used energy in MeV without conversion to J. Some rearranged incorrectly and attempted speed of light squared divided by energy despite its enormous value.

22 (b) (i) About half of the candidates scored at least 3 marks, with most of the rest gaining some credit. Answers were set out well and students displayed good overall knowledge and understanding of the cyclotron. Many candidates were not awarded particular marks through lack of sufficient detail, such as not stating just what it was the magnetic field was perpendicular to. The most common actual errors were in referring to the position of the charged particles at key points, i.e. when they were being accelerated linearly and when the polarity of the dees changed, students reversing the correct positions of between the dees and in the dees respectively.

22 (b) (ii) This proved straightforward to a sizeable proportion of the entry who gained full marks. The most common error among those who did not was to use the diameter rather than the radius and the next was using electron mass instead of proton mass. The unit was omitted by a fair few candidates and Wb was sometimes used instead of T.

**Paper Summary**

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

Where you are asked to make a judgement or come to a conclusion by command words such as ‘deduce whether’, you must make a clear statement, including any values being compared.

Learn standard descriptions of physical processes, and required procedures, 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.

When substituting in an equation with a power term, e.g. x2, don’t suddenly miss off the index when substituting or forget it in the calculation.

Be sure you know the command words and understand the level of required response for each of them, e.g. explain would mean a candidate must say why something happens and not just describe what happens.

Physical quantities have a magnitude and a unit and both must be given in answers to numerical questions.

When using graphs, read the scale values on either side of the point of interest to ensure you are using the scale correctly.

Familiarise yourself thoroughly with the formula sheet provided and be sure you know what each symbols stands for, not confusing similar symbols such as *v* for speed with *V* for potential difference.