Examiners' Report
Principal Examiner Feedback

October 2022

Pearson Edexcel International Advanced Level
In Physics (WPH14)
Unit 4 Further Mechanics, Fields and Particles

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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 remembering to apply the charge 2e for a helium nucleus or using the potential difference or distance half way between plates. They also knew some significant points in explanations linked to standard situations, such as electromagnetic induction, high energy particle collisions to create high mass particles and horizontal motion where vertical forces are involved, 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	87
2	79
3	71
4	76
5	84
6	36
7	86
8	62
9	50
10	79

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

11a

Most candidates were able to describe the structure of mesons correctly as a quark and an antiquark, although some used the less precise phrase ‘quarks and antiquarks’ and were not awarded the mark. A small minority only gave specific examples, such as up anti-down, which was not sufficient.

11b
About half of the entry were credited here for stating a relevant property, quite often beyond this specification, such as not affected by the strong force. Some lacked the required detail by stating just L = 1 rather than L = 1 or –1.

11c
A majority of candidates gained some credit for their response, with about a quarter receiving full marks. While most were able to apply conservation of charge, many concentrated on this aspect and did not give sufficient consideration to lepton number. A fair number incorrectly assumed that a pion was a lepton and concluded that the student was not correct as a consequence.

12a
Most candidates were able to draw a recognisable capacitor discharge curve, although some did not start on the y axis and some were drawn without due care so that had an increase in current at the end. Of those with correct curves, about half labelled the graph with the required initial current. Few candidates went on to apply the time constant to the graph.

12b
As is common with such ‘deduce whether’ questions, a variety of approaches were possible and a majority of candidates were able to make a relevant starting calculation for one of them. Of those, over a third went on to gain full marks. Candidates were generally able to apply an exponential decay formula to a relevant quantity. Not all candidates used a suitable comparison when drawing their final conclusion and some with a correct final value were not sure about what to compare it with or misinterpreted it, for example calculating a time of 0.53 s and saying this is less than 2.0 ms, so it meets the requirement.

13a
Well over half of the candidates scored full marks for tis question. Of those who did not, nearly all could apply either the eV conversion or mc^2, although some reversed them. A substantial minority completed the mass calculation but did not make an explicit comparison to justify the 100 times factor, for example by calculating the mass ratio of 97.

13b
About half of candidates were able to refer to mass-energy conservation or $E = mc^2$, but relatively few applied sufficient detail to the rest of their explanation of why high energies were needed, for example by stating that the Z boson mass is much higher than the mass of the protons. Candidates also rarely mentioned that the extra energy required for the particle formation had to be supplied by the kinetic energy of the protons.
Quite a few candidates gave answers relevant to a different type of particle physics experiment into the structure of nucleons, referring to high energies needed to overcome repulsive forces or to give a very small de Broglie wavelength. These are two quite different situations and candidates should take care to establish which type of collider experiment is involved.

13c
About half of the entry gained one of the marks, with nearly a third gaining both. Candidates tended to omit reference to either relativity or to the speed being near the speed of light. Stating ‘relativistic speeds’ was not sufficient for the latter.

14
As well as their knowledge and understanding of electromagnetic induction, this question assessed candidates’ ability to give coherent and logically structured answers, which, in most cases, they did.
The spread of marks was fairly even between 1 and 4, with relatively few gaining full marks.

The first three points were clearly familiar to most candidates, the lack of specific details in their answers being the block on receiving marks. For example, candidates frequently referred only to flux and not flux linkage, stated that emf was produced rather than induced or did not link the current to a conducting circuit. When a current was mentioned, an explicit link to the production of a magnetic field was rarely made.
Lenz's law was usually invoked, by name or by reference to opposing forces, but rarely applied with sufficient clarity to the specific situation.
Most candidates correctly stated that the magnet would take longer to fall through tube A, but usually assumed incorrectly that this was because there was no current in tube B because of the gap.

15a
This question required comparisons, but many candidates only made straightforward statements about a particular type of radiation without reference to another type. For example, 'alpha has high mass' rather than 'alpha has much higher mass than beta' or 'gamma is very penetrating' rather than 'gamma is much more penetrating than alpha'.
The second, consequential point in each pair was rarely made even when the initial comparison was satisfactory.

15bi
The typical mark for this question was 2. The vast majority included arrows in the correct direction, but many missed one of the other marks. The main reasons were failing to use a ruler, starting the lines from the central point or not distributing the lines equally – especially difficult for those who chose an odd number of lines.

15bii
Candidates usually measured the distance to the two equipotential lines correctly. Having measured 1 cm for 40 V and 4 cm for 10 V, many candidates assumed that the spacing would be equally spaced at 1 cm for 10 V, forgetting the increased spacing with increased distance for a point charge equipotential lines they would have shown had they been asked to draw them.
Candidates often knew that they should apply the formula for electric potential, but were not able to do this in a general way and relate it to the ratio of the distances. In an attempt to get some numbers, some tried to carry out calculations based on the charge of the nucleus, often using an incorrect proton number, and the actual distance in cm from the diagram. They should have realised that they are not required to remember proton number for any element other than hydrogen or helium so, if the data wasn't given, it wasn't required for the question.

15biii
A lot of candidates made a lot more work for themselves by converting to J, calculating the difference and then converting back to eV rather than just using $W = QV$. Whichever approach they took, a fair proportion neglected to apply the proton number of 2 for the alpha particle.
Having made some spurious calculation of potential energy using measured distance and charge of the nucleus in part (b) (ii), some candidates tried, unsuccessfully, to apply it in part (iii).

16a
Majority of candidates were able to complete this straightforwardly, although some got confused with radians and introduced an unnecessary factor of pi.

16bi
About a third of the candidates did not appear to know how to use a scaled vector diagram and some did not attempt one.
The majority gained credit for calculating momentum and at least one other mark for the diagram. Having a vector on the page at the start helped some candidates to apply a scale for vector length. They tended to be less careful about using a protractor for correct angles and

quite a few assumed incorrectly that the angle between the initial and final momentum of the ball was 90°.
Of those who completed the required diagram, not all candidates made it clear what they were measuring for a comparison for their conclusion.
Although the question required use of a scaled diagram, not many candidates made their deduction by calculation, for example using components or the cosine rule. They were allowed the final mark if they completed this correctly and made the correct conclusion.

16bii
The majority gained credit for this question, for calculating kinetic energy if nothing else, and almost a third gained full marks. A substantial minority completed all of the calculations correctly but either did not make a conclusion, or made a conclusion but did not justify it with a comparison of the initial and final kinetic energy.

17a
This question was about a standard derivation required by the specification. Nearly half of the entry gained at least one mark, the most common single mark being for the diagram. Even so, quite a few who included a diagram omitted correct arrows or labels. A substantial minority gained either 4 or 5 marks, those with 4 marks usually missing a relevant reference to the small angle approximation.

17bi
Again, nearly half of the entry gained at least one mark, the most common single mark being for the idea that the vertical component of lift equals the weight, although quite a few reversed these. Having established this, relatively few referred to the consequent lack of vertical acceleration. Some candidates referred to the resultant force being ‘towards the centre’, which was not sufficient. Those candidates who identified the resultant force as horizontal usually linked it to circular motion successfully.

17bii
A good majority of candidates scored for this question, with nearly a third being awarded full marks. A fairly common error was to take lift and centripetal force as vertical and horizontal components of weight.

18ai
The great majority got this part correct straightforwardly. Candidates occasionally omitted the unit for their answer and so were not awarded the final mark as quantities require a magnitude and a unit.

18aii
Candidates generally made some headway with this, with almost a third completing it correctly and quite a few making the single mistake of not using half of the potential difference or distance between the plates.

18bi
Credit could not be given for the correct direction without a full explanation including the direction of the magnetic force, so full marks were awarded infrequently. Many did not distinguish between forces and fields or went to great lengths to explain the direction of the current but not the force directions.

18bii
Nearly half of the candidates completed this successfully. Those who did not were often trying to use $r = mv/Bq$ even though they had been told that the ions were travelling in a straight line, so there was no relevant radius, and they had not been told their mass.

18c

Just over a quarter of the candidates gained credit for their responses to this question, often for stating that isotopes have different masses or clearly linking mass to the radius of the pass or both. Some candidates stated that isotopes have different charges.

Candidates rarely identified all of the quantities remaining constant. Referring to $r = mv/Bq$ helped with this.

Paper Summary

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

Learn the required derivations and show all steps and substitutions clearly.

Address all points specifically mentioned in questions, such as the use of a vector diagram.

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.

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. There will always be at least two linked marking points for a question asking you to ‘explain’.

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

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.

Explanations can often be supported by reference to formulae on the data, formulae and relationships sheet.

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