Examiners' Report
Principal Examiner Feedback

January 2023

Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH14)

Paper 01: Further mechanics, fields and particles

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General Comment

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 accounting for the energy of two particles in an annihilation event or applying their knowledge that a 90° turn represented a quarter of a full circle. 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 electron diffraction, 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	91
2	89
3	60
4	52
5	76
6	90
7	74
8	79
9	44
10	49

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

11a
The great majority of candidates could state a suitable difference between a positron and an electron, although some omitted key points, such as to which value they were applying positive and negative values and some simply said different charges without specifying that they were of opposite sign.

11b
Most candidates gained credit here, with about a third achieving full marks. Conservation of charge was explained by about two thirds of the entry, but about half of these had less success with lepton number.

12a
About half of the candidates gained credit for at least two concentric circles to show equipotential lines, many others drawing them but not achieving a mark because they drew radial field lines as well and didn’t add labels to show which was which. About a third of those who successfully drew the equipotential lines did so with increasing spacing, many others very carefully but incorrectly showing equal spacing.

12b
Most candidates completed this calculation straightforwardly. Some omitted the index 2 for r squared when they substituted, and some substituted fully but didn’t square the distance at the calculation stage. Occasionally candidates were limited to one mark because they omitted the unit.

12c
Only a minority completed this part successfully by calculating the potential energy at the two positions and finding the difference. Candidates were far more likely to try to apply work = force x distance, failing to take into account that the force is not constant. Others applied the correct equation for potential difference, but only once with the difference between the distances in the denominator rather than twice with each distance in turn.

13ai
A majority of candidates calculated the correct radius. They did not all gain full marks, however, because they did not include sufficient detail in their solutions. This was a ‘show that’ question, so it was necessary to show the steps in their calculation clearly. Some used $r = v^2/g$ tan theta directly. This is not an equation from the specification, so it needs justification by reference to a triangle of forces or the use of components. Similarly for the use of tan theta = F_C / mg.
Of those who could not complete the calculation, many were awarded a single mark for the use of $W = mg$ only because they treated lift as equal to a component of weight rather than the reverse.

13aii
The method for calculation of time for a circular path did not present particular difficulties, but a surprising number of candidates failed to convert 90° to a quarter of a full circle.

13b
Many realised that lift would now be greater than weight, but most simply stated that the aeroplane would now move upwards without reference to acceleration, indication a lack of detailed knowledge of Newton’s first law of motion.

14a
Most candidates were able to make a correct statement, but they rarely included sufficient detail for two marks. While a majority mentioned ‘total’, many did not. Similarly, there were many references to ‘no external forces’ but very few to ‘no resultant external force’.

14bi
Few candidates could not apply the kinetic energy equation correctly, with most gaining full marks, but a substantial proportion did not make a clear statement in conclusion and so did not gain the third mark.

14bii

Almost a fifth of the entry did not gain even the first mark for applying the momentum equation, many of these getting their conservation laws confused and calculating kinetic energy instead. Of the rest a majority were able to complete the calculations for the *x* direction, although some confused sine and cosine. Quite a few, however, stopped at that point and neglected the perpendicular direction. Of those completing all calculations correctly, a substantial minority did not gain the fifth mark because they did not make a clear conclusion including both directions.

15a

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 5, 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 path. When a current was mentioned, an explicit link to the production of a magnetic field was often omitted.

Lenz's law was usually invoked, by name or by reference to opposing forces, but not always applied with sufficient clarity to the specific situation.

15b

A third of the entry gained full marks for this question, with about a half gaining at least two marks. Some candidates already knew $E = Blv$, some derived it and many were able to progress by applying rate of change of flux linkage and flux linkage = BA. When applying speed to calculate time, a fair number used the length of the magnet instead of the height.

16a

Candidates often appeared to be answering a different question about how to correct the circuit. There were often fairly vague references to series and parallel. Some candidates interpreted the circuit symbol for the switch as a direct representation and said that it wasn't long enough to reach X or Y. Of the quarter of the entry gaining only one mark, this was more frequently for a comment on the voltmeter than the resistor.

16bi

This part was generally answered well, with most candidates taking values of potential difference at $t = 0$ s and another time and using the logarithmic form of the exponential decay equation. Students occasionally misread the vertical scale, where one small square was 0.2 V and not 0.1 V, because they only looked at the *y*-value below the point in question and assumed the increment without checking. The unit was sometimes omitted.

16bii

Candidates approached this question as if the decrease in potential difference was a straight line by calculating current from V/R at the two times and finding the average of those two values. Only infrequently did a candidate calculate the charge at the two times, calculate the change in charge and divide by time.

16biii

The fundamental error in the previous part was often carried over to this part by candidates attempting to use their incorrectly calculated value of current in I^2Rt. Many candidates did now use the correct equation for the energy stored by a capacitor, although they sometimes only did it for one value of potential difference. Quite a few used the difference in potential differences in a single calculation, ignoring the fact that the difference of two squares is not the same as the square of the difference.

17ai

The great majority were able to complete this in the required detail for full marks. Some had a slight problem with one equation from the paper using a large Q and one using a small q, but it is their responsibility to familiarise themselves with the list at the back of the paper. Some candidates also made difficulties for themselves by not making the difference between large V for potential difference and small v for velocity clear.

17aii

Nearly all got both marks for this, with an occasional conversion problem for cm to m.

17aiii

Most were able to apply the cyclotron equation and momentum to make a start, and a third completed this fully, including a correct conclusion that the value is not consistent with the accepted value. A surprising number thought that 1.3 was close enough to 1.8 to incorrectly say that the result is consistent.

17b

Only about half of the entry realised that this was about electron diffraction. Others thought this was related to alpha scattering and the plum pudding model or to ideas from Chemistry about electron clouds.

Those who did recognise the situation usually mentioned wave behaviour of electrons and often mentioned diffraction. It was less common to see an explicit statement that diffraction is wave behaviour or not particle behaviour.

18ai

Over half of the entry described either quarks as pairs or the number of quarks matching the number of leptons. They less frequently made a clear link between the sixth quark and the bottom quark or the sixth quark and the sixth lepton. The symmetry of the model was rarely mentioned. Quite a few thought the pairs of particles in the table were particle-antiparticle pairs.

18aii

The great majority identified the categories of hadron, but some gave specific examples instead of the more general categories. Some confused muons with mesons.

18bi

Just over a third of the candidates gained credit here. Many more had the idea but could not make the required points with sufficient clarity or detail. Some answered a different question about a 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.

Those discussing the correct situation tended to have an idea that there was more energy for particle formation, but rarely linked this to kinetic energy of the colliding particles. They sometimes knew that conservation of momentum was involved, but could not say how this made more of the kinetic energy available. They also tended to know that this was linked to the formation of large particles, but did not always use a comparative term, such as more massive, and sometimes even said heavier, which is not accepted.

18bii

The great majority could convert from eV to J, and most knew to subtract rest energy from total energy, but they frequently got confused about how to apply this to two particles before and two particles after, usually doubling and halving inconsistently.

18biii

Most candidates who made headway with this took the expected route of calculating mass in kg and then using the non-relativistic kinetic energy equation with varying degrees of success. Those obtaining the expected speed did not always compare with the speed of light for a conclusion.

A few candidates knew the relativistic mass equation and applied it successfully.

18c

The majority were able to state that lifetime increases, but few realised that this applies to the observer only and would affect the hadronization time in the same proportion.

Paper Summary

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

When substituting in an equation with a power term, e.g. r^2, don't suddenly miss off the index when substituting or forget it in the calculation.

When a calculation question starts with 'show that', you are required to show all steps in your calculation and to give your final answer to at least one additional significant figure.

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.

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' or 'deduce whether', must make a clear statement, including any values being compared. If it is a numerical comparison you must show all steps in your calculation.

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.