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Examiners' Report/ Principal Examiner Feedback

January 2014

IAL Physics (WPH04/01)

Unit 4: Physics on the Move

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Candidates found this paper accessible and were able to attempt all of the questions knowing the topic of physics that was being answered. Even where candidates failed to score marks due to lack of detail or the use of imprecise language, their answers were still relevant to the question being asked. Candidates were able to apply their knowledge to a variety of styles of examination questions.

Question 13 was not very well answered because candidates immediately thought of electromagnetic induction rather than the force on charged particles when moving at an angle to a magnetic field. This meant that they could start the question but could not make much progress without considering the effect of the accumulation of charge on the wing tips and the electric field that would build up.

Question17 was about an electron following a helical path where there is circular motion in one direction and uniform motion in a perpendicular direction. This hasn't specifically been examiner before and consequently when candidates were asked to explain the path, the vast majority just quoted a mark scheme that they had learnt about why a particle moves in a circle. We know that some candidates learn mark schemes but they must understand that the answer they write must be relevant to the question they are answering.

This was also noticed in question 11 where candidates needed to apply Fleming's left hand rule. Because there are a number of different ways this might be expressed, we often use the phrase 'refers to Fleming's left hand rule' in the mark scheme. This means that the examiner is looking for evidence that the candidate has used the rule. It might be for identifying the direction of the force or the current. Frequently, in scripts, candidates will just quote that phrase as part of their answer. Of course it does not gain credit but is an indication to us that candidates learn by rote mark schemes and then quote them back.

Candidates need to read the questions carefully and think about the context and remind themselves of the context as they work through the question. In the main, calculations were well done although many struggled with the capacitance calculation in question 15(b)(ii) not realising that having found R from $R = V/I$, all they had to do was to use $t = RC$ to find C.

Both question 14 and 17 required candidates to use a component of force and despite the questions being written to get the candidates to find the components initially, many candidates then failed to use this component.

The command words in questions are important and candidates need to think carefully about what they have been asked to do. This was particularly relevant in Q15.

Candidates achieved well on the multiple choice questions with A grade candidates often scoring 10 marks and E grade candidates scoring about 7 marks. Q7 was very badly answered. I am sure that most candidates could explain that a uniform electric field exerts the same force on a charged object wherever the object is in the field, but they were unable to apply this knowledge to a graphical representation of force and position.

Question	Topic	% correct	Most common incorrect response
1	Units for electric field strength	94	-
2	Angular speed calculation	78	C
3	Momentum from a graph	85	B
4	Electric force between charged particles	63	A/B
5	Capacitor calculation	84	D
6	Electromagnetic induction	74	D
7	Graphical interpretation of electric fields	38	B
8	Acceleration of particle in electric field	71	C
9	Proton, neutron, electron numbers	89	-
10	MeV/c^2 to kg conversion	85	-

11. There were a few excellently worded answers to this question however most candidates had difficulty with expressing themselves clearly enough to obtain full credit. The majority scored the marks for charge and direction of the particle. Many were able to state that the correct change in the radius of curvature of the particle as it passes through the lead sheet but they usually just related this to a loss in energy rather than to the reduced speed or kinetic energy. When explaining why the charge was negative, many candidates just wrote ‘particle moves opposite to current’ with no or little explanation as to why the current is in a particular direction. Candidates often quoted Fleming’s left hand rule or just referred to it without actually applying it.

12. It was clear from the candidates’ work that most students had some knowledge of the Linac and some candidates were able to score full marks for this question. The majority did not because they have difficulty in organising their responses or they are writing at length about one physics point and so are not providing enough detail to score more marks. Four marks means that four different physics points are needed. The mark most commonly scored was for the length of tubes increasing so that the particles were in each tube for the same time. Unfortunately not many candidates were able to relate this to the fact that the frequency of the supply was constant. Quite a few candidates scored the mark for the acceleration being in the gap between the tubes but not many candidates realise that the polarity changes midway through the tubes. The majority think it happens as the particles leave a tube. This is an A2 paper assessing candidates understanding of fields and so there was an expectation that they would refer to an electric field, not many did. An answer just in terms of electrostatic attraction and repulsion is a GCSE type response and will not score marks.

13 This question was about a conductor moving at an angle to a magnetic field so that the conduction electrons experienced a force causing them to move to the tips of the wings. Since there is not a closed conduction loop, the accumulation of charge on the tips creates an electric field that provides an electric force that opposes the further build-up of charge.

The ideal answer for (b)(i) was in terms of the wing moving at an angle to the magnetic field and a force on the electrons perpendicular to both of the other directions. Credit was given to answers in terms of flux cutting and an induced e.m.f. and this is how virtually all of the candidates answered this part of the question. These candidates were then focused on induced e.m.f. when answering (b)(ii) and completely missed the idea of an opposing force. Quite a few candidates were able to identify that at constant speed there was a constant rate of change of flux but they then stated that there was no e.m.f. These candidates scored no marks for this section. Section (b)(iv) was also very poorly answered with a large number of candidates thinking that there was simply no magnetic field at the equator. More able candidates realised that the orientation of the plane with respect to the magnetic field was important but then they were too unspecific to score marks.

14(a)(i). This was well answered with many candidates scoring both marks. The candidates were asked to show that the reaction force was about 1700 N but quite a few started with the force and found a mass of 81 kg. This is what we call a 'reverse show that'. In this question there were only two marks and so this method still scored both marks. However if a 'show that' is worth three or more mark, there is a one mark penalty for a reverse show that.

14(a)(ii). Many candidates used the force from (a)(i) instead of the component of the force for the centripetal acceleration and so scored no marks. These candidates were allowed an ecf of their incorrect acceleration in (a)(iii). There were many good responses to (c).

Some candidates lost a mark because having identified that because of the reduced mass of a child, there is a smaller centripetal force, they then went on to say that the acceleration was also less. That wrong statement meant that only the reduced mass mark was awarded. A few candidates decided to abandon physics entirely and gave some interesting social comments e.g. adults have a more sedentary life, active children would not be so sensitive to circular motion, children have less fear and so enjoy the ride more. It is worth reminding candidates that all of the marks on physics papers are for points of physics only.

15(a)(i) The command word in this question was explain and not describe and so answers such as 'the potential difference for the resistor fell exponentially' did not score any marks. The marks were for why this was happening and specifically what happened to the capacitor when the switch was closed. Quite a few candidates scored one mark for a general statement that the voltage across the resistor decreased as the voltage across the capacitor increased.

(a)(ii) Most candidates scored 1 mark for an exponential graph with a decreasing gradient although quite a few draw one with an increasing gradient. Only a small percentage of candidates realised that since the resistor had a p.d. at t = 50 s the maximum p.d. across the capacitor would not be 12V.

(a)(iii) Another part where the command words were ignored. The question asked how the graph could be used to find the time constant. This means that the candidate must refer to the graph. Just saying 'it is the time for the p.d. falls to 37% of its value' is not good enough. That answer scored 1 mark for showing an understanding of half-life. A model answer would be 'calculate 37% of the initial value of the p.d. and read the time corresponding to this value from the graph.' Some candidates were confused by 37% and 63%, mixing up whether this was the new value or the change. There are two different methods using tangents and so candidates needed to be specific in their answers, just saying draw a tangent was not enough. Candidates could score marks either from referencing the printed graph or the graph they had drawn. Some candidates simply wrote exponential equations with no word of explanation and scored no marks.

(b) Quite a few candidates scored full marks on this section and they were the ones who realised that use of $R = V/I$ gave them current and use of $RC =$ 25 s. Some candidates tried to find C first and invariably made mistakes. The other common mistake was to make errors in converting mA to A.

Q16(a)(i) This was done as a 'show that' so that candidates could progress through the question, knowing that the lighter truck came to rest. As with all show that questions there is an expectation that candidates will show their working. Many candidates correctly wrote an equation expressing conservation of momentum but showed no working and went straight to a statement that v was zero, losing a mark. Some candidates tried to do a conservation of kinetic energy calculation but since this was prior to them knowing anything about the collision, it was not an accepted alternative.

(a)(ii) The graph did not go down to zero on the y-axis but this did not seem to affect the students who assumed that it did. The vast majority drew a graph which reached the bottom of the y axis at the same time as the heavier truck finished its collision (accepted due to scale problems). The most common wrong graphs had the speed of the lighter truck either dropping instantly to zero or only dropping to become the same final speed as the heavier truck.

(a)(iii)This was generally well answered and where errors were made, it was not working out a change in momentum or dividing by 10 instead of 0.1 s.

(b)(i) An elastic collision is defined in terms of kinetic energy since momentum is conserved in all collisions. However many candidates felt the need to write down that both momentum and kinetic energy were conserved.

(b)(ii)The question asked the candidates to find the kinetic energy at the end and at the half way point of the collision which was not the crossover point for the majority of the graphs. However many candidates did not read the question properly and used the crossover point. Weaker candidates who realised that they needed to use the kinetic energy formula forgot the square the velocity.

(b)(iii) Hardly any candidates scored this mark. There were many references to energy lost as sound /heat which 0f course implies that they had not thought about the situation where they were meant to be explaining why there appeared to be an increase in energy. Even some of those who appreciated that it was to do with the buffers failed to refer to elastic potential energy.

Question17 provided very good discrimination with the able candidates scoring very well and with weaker candidates being able to pick up some marks. In order to perform well in this question candidates had to appreciate that the vertical component of the electron’s velocity resulted in circular motion in a vertical plane while the horizontal component of velocity remained unchanged. In order to help candidates understand what was happening, the question started by asking the candidates to find a horizontal and a vertical component of the electron’s velocity this was very simple and generally correctly done. This was done to encourage the candidates to think about a motion at right angles to the magnetic field and one parallel to the magnetic field so that they could answer the question about explaining the helical path. Unfortunately hardly any candidates thought about this question and just gave a general answer in terms of a force at right angles to a velocity causing circular motion which out any reference to which component of velocity they were referring to.

Consequently hardly any candidates scored marks for (a)(iii). Parts (b)(i) and (b)(ii) were about the circular part of the motion and so candidates needed to use the vertical component of velocity. Many candidates lost marks because they just used the electron’s velocity of 8.0×10^{6} m s^{-1}.Similarly (b)(iii) was about the distance between the loops and this meant using the time found in (ii) with the horizontal component of velocity. Weaker candidates really struggled with this and they were quite inventive in the physics they tried to use. Part (c) was often well done even by candidates who had used the wrong component of velocity at various stages in the question. Where marks were lost it was for statements such as there would be fewer loops or the path would be shorter.

18 (a)(i) Most candidates were able to state that the charge was negative and to relate this to conservation of charge. The expectation was that since the omega particle had a strangeness of −3, candidates would identify that 3 quarks were needed hence it was a baryon. Baryon number is not on the specification and there is no requirement for candidates to know about conservation of Baryon number. If candidates have been taught about Baryon number they should also be taught that to apply its conservation, requires stating the Baryon number of all the particle in the interaction. Those candidates who stated that it was a baryon to conserve Baryon number did not get the mark.

(a)(ii) All five possible marking outcomes scored nearly equal weightings. The proton was the most commonly correct particle, followed by the charged kaons and the neutral kaon being the most wrongly identified particle. The most common error was to say that the neutral kaon consisted of an anti-down quark and a strange quark. This would have given the correct charge for the particle but would have given it a strangeness of +1 which meant that strangeness would not have been conserved in the interaction.

(b)(i)This again showed candidates continuing lack of understanding of the units used in particle physics. It was rare to award three marks and even when candidates got to the right answer they invariably followed it with some sort of wrong conversion involving *e* or c^2. Candidates did not seem to realise that initially they needed to find a difference in mass in MeV/c^2 between the two sides of the interaction. Some candidates did not seem to realise that they needed to subtract the mass of the two protons from the left hand side and sometimes the mass of two protons was subtracted form a mass on the right hand side that did not include the mass of the proton on that side. Most candidates did realise that a division by two was needed but failed to realise that a mass of 200 MeV/c^2 is equivalent tot an energy of 200 GeV.

(b)(ii)It was very rare for any marks to be awarded. Candidates do not understand the implications of a head-on collision and a fixed target collision in terms of conservation of momentum and mass energy conservation. The majority of candidates did not even mention momentum and those that did, often expressed themselves badly and wrote that momentum would not be conserved.

Summary

Key points to help students improve their performance are

- Thoroughly learn key facts and definitions.
- Become familiar with the units used in particle physics
- Read the questions carefully and answer the question that is asked.
- Take note of the command words in the question.
- For context based questions, always think for a moment before starting to answer the question.
- .For long questions as you move through the various parts, reread the stem of the question to remind yourself what is says.

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