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General Certificate of Education (A-level)
January 2012

Physics A PHYA4

(Specification 2450)

Unit 4: Fields and further mechanics

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from: aqa.org.uk

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Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA4, Fields and Further Mechanics

Section A

This component is an objective test for which the following list indicates the correct answers used in marking the students' responses.

	Keys to Objective Test Questions													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
	A	D	C	C	B	D	A	A	D	C	B	B	A	
	14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**		
	D	C	D	C	D	D	B	B	A	B	C	A		

Section B

Question 1			
a		work done [or energy needed] per unit charge [**or** (change in) electric pe per unit charge] ✓ on [or of] a (small) positive (test) charge ✓ in moving the charge from infinity (to the point) ✓ [**not** from the point to infinity] ✓	**3**
b	i	$V = \frac{Q}{4\pi\varepsilon_0 r}$ gives Q ($=4\pi\varepsilon_0 rV$) = $4\pi \times 8.85 \times 10^{-12} \times 0.30 \times 3.0$ ✓ = 1.0×10^{-10} (C) ✓ to **2 sf** only ✓	**3**
b	ii	use of $V \propto \frac{1}{r}$ gives $V_M = \frac{V_L}{3}$ ✓ (= (+) 1.0 V)	**1**
b	iii	$E \left(= \frac{Q}{4\pi\varepsilon_0 r^2}\right) = \frac{1.0 \times 10^{-10}}{4\pi \times 8.85 \times 10^{-12} \times 0.60^2}$ ✓ (= 2.50 V m^{-1})	**1**
c	i	uniformly spaced vertical parallel lines which start and end on plates ✓ relevant lines with arrow(s) pointing only downwards ✓	**2**
c	ii	= 3.3(3) (V m^{-1}) ✓	**1**
c	iii	part (b) is a radial field whilst part (c) is a uniform field ✓ [**or** field lines become further apart between **L** and **M** but are equally spaced between **R** and **S**]	**1**
		Total	**12**

Question 2			
a		charge (stored) ✓ per unit potential difference ✓ [**or** $C = Q/V$ where Q = charge (stored by one plate) ✓ V = pd (across plates) ✓]	**2**
b	i	$C\left(=\frac{Q}{V}\right) = \frac{13.2\times10^{-6}}{6.0}$ ✓ = 2.2×10^{-6} (F) ✓ (or 2.2 μF)	**2**
b	ii	when t = time constant $Q = 0.63 \times 13.2 = 8.3$ (μC) ✓ [**or** = 0.63 × 13(.0) (from graph) = 8.2 (μC)] reading from graph gives time constant = 15 (± 1) (ms) ✓	**2**
b	iii	resistance of resistor = $\left(=\frac{\text{time constant}}{C}\right) = \frac{15\times10^{-3}}{2.2\times10^{-6}}$ = 6820 (Ω) ✓	**1**
b	iv	gradient = current ✓	**1**
c	i	maximum current = $\left(=\frac{V}{R}\right) = \frac{6.0}{6820}$ = 0.88 (mA) ✓ [**or** value from initial gradient of graph: allow 0.70 – 1.00 mA for this approach]	**1**
c	ii	curve starts at marked I_{max} on I axis and has decreasing negative gradient ✓ line is asymptotic to t axis and approaches ≈ 0 by t = 60 ms ✓	**2**
		Total	**11**

Question 3			
a	i	speed at P, v (= $\sqrt{2gh}$) = $\sqrt{2 \times 9.81 \times 25}$ ✓ = 22(.1) (m s^{-1}) ✓	**2**
a	ii	use of $F = k\Delta L$ gives $d\left(=\frac{F}{k}\right) = \frac{58\times9.81}{54}$ ✓ = 11 (10.5) (m) ✓	**2**
b	i	period $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{58}{54}}$ ✓ (= 6.51 s) time for one half oscillation = 3.3 (3.26) (s) ✓	**2**
b	ii	frequency $f\left(=\frac{1}{T}\right) = \frac{1}{6.51}$ ✓ (= 0.154 (Hz)) use of $v = \pm 2\pi f\sqrt{A^2 - x^2}$ when x = 10.5 m and v = 22.1 m s^{-1} gives $22.1^2 = 4\pi^2 \times 0.154^2\,(A^2 - 10.5^2)$ ✓ from which A = 25.1 (m) ✓ [**alternatively**, using energy approach gives $\frac{1}{2} m v_P^2 + mg\Delta L = \frac{1}{2} k(\Delta L)^2$ ✓ ∴ $(29 \times 22.1^2) + (58 \times 9.81 \times \Delta L) = 27\,(\Delta L)^2$ solution of this quadratic equation gives ΔL = 35.7 (m) ✓ from which A = 25.2 (m) ✓]	**3**

c		bungee cord becomes slack ✓ student's motion is under gravity (until she returns to **P**) ✓ has constant downwards acceleration **or** acceleration is not $\propto$ displacement ✓	**max 2**
d	i	when student is at **R** or at bottom of oscillation ✓	**1**
d	ii	at uppermost point **or** where it is attached to the railing ✓ because stress = *F*/*A* and force at this point includes weight of whole cord ✓ [accept alternative answers referring to mid-point of cord because cord will show thinning there as it stretches **or** near knots at top or bottom of cord where *A* will smaller with a reference to stress = *F*/*A*]	**2**
		Total	**14**

Question 4			
a	i	use of $\frac{N_S}{N_P} = \frac{V_S}{V_P}$ gives N_S = $\frac{12 \times 1150}{230}$= 60 (turns) ✓	**1**
a	ii	max output power = 0.85 × 0.630 × 230 ✓ (= 123 W) max number of lamps $\left(= \frac{123}{24}\right)$ = 5 ✓ (no mark for non-integer answer) [**or** efficiency = $\frac{I_S V_S}{I_P V_P}$ gives 0.85 = $\frac{I_S \times 12}{0.630 \times 230}$ ✓ (and max I_S = 10.3 (A)) max number of lamps $\left(= \frac{10.3}{2.0}\right)$ = 5 ✓]	**2**
a	iii	fuse prevents transformer from overheating [**or** prevents transformer from supplying excessive currents] ✓	**1**
a	iv	(all of) transformer is disconnected from supply when fuse fails [**or** fuse in secondary circuit would leave primary circuit live] ✓	**1**

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<td>b i</td>
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The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High level (good to excellent) 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate states that the ac in the coil produces a constantly changing magnetic field that passes through the ring, causing an emf to be induced according to Faraday's law.

The candidate recognises that the induced emf will cause a current to flow in the ring, that the current is likely be large because the coil acts as a single conductor with low resistance, and that this current also produces a magnetic field.

The candidate appreciates that Lenz's law indicates that the direction of the induced current is such as to produce a magnetic field that will oppose the existing field, and that the two fields will interact.

The candidate refers to the force that acts on a current-carrying conductor when it is in a magnetic field and that this force lifts the ring upwards (into an area where the magnetic field is weaker) until the upwards magnetic force is equal to the downwards weight of the ring.

Intermediate level (modest to adequate) 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate is familiar with either or both Faraday's and Lenz's laws but only applies one of them to explain what happens in this demonstration. There are correct references to the two forces that act on the ring, and a reasonable explanation of why the ring reaches a stable position.

Low level (poor to limited) 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

The candidate refers much more superficially to either Faraday's or Lenz's law (or to both of them) but shows some understanding of why the forces acting on the ring cause it to reach equilibrium.

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	The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. **Faraday's law** • An emf is induced whenever there is a change in the magnetic flux passing through a conductor. • The magnitude of the emf is proportional to the rate of change of magnetic flux linkage. • The induced emf will cause a current to flow in any complete circuit, such as a single conducting ring. • Because the ring is made from aluminium, which is a good conductor, a large initial current will be induced in it. **Lenz's law** • The induced current flows in such a direction as to oppose the increase in magnetic flux when the current is switched on in the coil. • The current produces a magnetic field in the opposite direction to that produced by the coil. • These two (alternating) fields interact like the fields between two facing like magnetic poles, giving repulsion. **Forces** • The ring is a current-carrying conductor in a magnetic field, and consequently it experiences a force. • This magnetic force acts upwards, in the opposite direction to the weight of the ring. • As the ring rises, the magnetic field to which it is exposed becomes weaker as it moves away from the coil. • This reduces the induced current, reducing also the magnetic force on the ring. • The ring reaches a stable height when the magnetic force has decreased to the point where it is equal to the weight of the ring.	
b ii	ring would 'float' higher [**or** be expelled upwards] ✓ because (initial) current or emf (induced) *in ring* is greater ✓ **or** ring moves into weaker field until magnetic force balances weight [**or** (initially) magnetic force exceeds weight] ✓	**max 2**
	Total	**13**

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