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General Certificate of Education (A-level)
June 2011

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 candidates' 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 candidates' 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 candidates' 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 candidates' responses.

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

Section B

Question 1		
a i	arrows to show *R* (or *N*) vertically up and *mg* (or *W*) vertically down and along the same line (within ± 2 mm) ✓	**1**
a ii	$mg - R = \frac{mv^2}{r}$ ∴ $R = mg - \frac{mv^2}{r}$ ✓ $\left[= m\left(g - \frac{v^2}{r}\right)\right]$	**1**
a iii	**use of** $R = m\left(g - \frac{v^2}{r}\right)$ gives R = $12\left(9.81 - \frac{11^2}{23}\right)$ ✓ = 55 (54.6) (N) ✓	**2**
b	*R* decreases (as *v* increases) ✓ because *mg* is unchanged but $\frac{mv^2}{r}$ is larger ✓ at higher speeds *R* becomes = 0 [**or** package is not in contact with the floor] ✓ supported by calculation eg when $v = 15\,\text{m s}^{-1}$, *R* = 0.33 N (or ≈ 0) ✓	**max 3**
	Total	**7**

Question 2		
a i	for one spring, change in force $\Delta F = k\Delta L = 30 \times 60 \times 10^{-3} = 1.8$ (N) ✓ resultant force (= [*F* + Δ*F*] – [*F* – Δ*F*]) = 2Δ*F* ✓ (= 3.6 N) **alternative** using answer from (b) (ii) $a = (2\pi f)^2 x = (2\pi \times 1.38)^2 \times 60 \times 10^{-3} = 4.51\,(\text{m s}^{-2})$ ✓ resultant force = *ma* = 0.80 × 4.51 ✓ (= 3.6 N)	**2**
a ii	acceleration $a \left(= \frac{F}{M}\right) = \frac{3.6}{0.8} = 4.5\,(\text{m s}^{-2})$ ✓ to the right ✓ **alternative** for first mark using answer from (b) (ii) $a = (2\pi f)^2 x = (2\pi \times 1.38)^2 \times 60 \times 10^{-3} = 4.5\,(\text{m s}^{-2})$ ✓	**2**

b	i	acceleration is proportional to displacement (from equilibrium position) ✓ acceleration is in opposite direction to displacement [**or** acceleration is towards a fixed point/equilibrium position] ✓	**2**
b	ii	$f = \frac{1}{2\pi}\sqrt{\frac{2 \times 30}{0.80}}$ ✓ (= 1.38 Hz) period $T\left(=\frac{1}{f}\right) = \frac{1}{1.38}$ = 0.73 (0.726) ✓ [or 730] s ✓ [ms]	**3**
c	i	$f = \left(= \frac{1}{2\pi}\sqrt{\frac{2k}{m}}\right) = \frac{1}{2\pi}\sqrt{\frac{2 \times 200}{1.0 \times 10^{-25}}}$ = $1.0(1) \times 10^{13}$ (Hz) ✓	**1**
c	ii	v_{max} (= $2\pi fA$) = $2\pi \times 10^{13} \times 10^{-11}$ = 630 (628) ($m\,s^{-1}$) ✓	**1**
c	iii	max E_K (= ½ mv_{max}^2) = ½ × $1.0 \times 10^{-25} \times 628^2 = 2.0 \times 10^{-20}$ (J) ✓ [or using ½ kA^2 approach]	**1**
		Total	**12**

Question 3			
a	i	energy stored by capacitor (= ½ CV^2) = ½ × 70 × 1.2^2 ✓ (= 50.4) = 50 (J) ✓ to **2 sf** only ✓	**3**
a	ii	energy stored by cell (= $I\,V\,t$) = $55 \times 10^{-3} \times 1.2 \times 10 \times 3600$ ✓ (= 2380 J) $\frac{\text{energy stored by cell}}{\text{energy stored by capacitor}} = \frac{2380}{50}$ = 48 (ie about 50) ✓	**2**
b		capacitor would be impossibly large (to fit in phone) ✓ capacitor would need recharging very frequently [**or** capacitor could only power the phone for a short time] ✓ capacitor voltage [**or** current supplied or charge] would fall continuously whilst in use ✓	**max 2**
		Total	**7**

Question 4			
a	i	magnetic field (or B) must be at right angles to velocity (or v) ✓	**1**
a	ii	F = (magnetic) force (on a charged particle or ion) B = **flux density** (of a magnetic field) Q = charge (of particle or ion) v = velocity [**or** speed] (of particle or ion) all four correct ✓	**1**
b	i	into plane of diagram ✓	**1**
b	ii	magnetic **force** = electric **force** [or $BQv = EQ$] ✓ these forces act in opposite directions [**or** are balanced **or resultant** vertical force is zero] ✓	**2**

b	iii	$BQv = EQ$ gives flux density $B = \frac{E}{v}$ ✓ $E\left(= \frac{V}{d}\right) = \frac{45}{65 \times 10^{-3}}$ ✓ (= 738 V m^{-1}) $B\left(= \frac{738}{1.7 \times 10^{5}}\right) = 4.3 \times 10^{-3}$ ✓ T ✓	**4**
c		ions would be deflected upwards ✓ magnetic force increases but electrostatic force is unchanged [**or** magnetic force now exceeds electrostatic force] ✓	**2**
		Total	**11**

Question 5			
a	i	current $I\left(= \frac{P}{V}\right) = \frac{500 \times 10^{3}}{25 \times 10^{3}}$ = 20 (A) ✓	**1**
a	ii	wasted power ($I^2 R$) = $20^2 \times 30 = 1.20 \times 10^4$ (W) (12.0 kW) ✓ power output from cables = 500 – 12 = 488 (kW) ✓ **or** voltage drop along cables = IR = 20 × 30 = 600 (V) ∴ output voltage = 25000 – 600 = 24400 (V) ✓ power output = IV = 20 × 24400 = 4.88×10^5 (W) ✓	**2**
a	iii	efficiency $\left(= \frac{P_{\text{out}}}{P_{\text{in}}}\right) = \frac{488}{500}$ × 100 = 98 (97.6) (%) ✓	**1**
b	i	primary coil must have more turns than secondary ✓	**1**
b	ii	to reduce heating (I^2R) loss [**or** energy/power/copper loss] ✓ (because) $I_S > I_P$ ✓ and R is reduced (by use of thicker wire) ✓	**max 2**
c		**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 provides a comprehensive and logical description of the main principles of the grid system. They should identify I^2R heating as the main cause of energy loss, and know that this can be reduced by using transformers to raise voltage and therefore decrease current (for the same power), and that transformers require ac. They may not have referred to safety and insulation issues that ultimately require the voltage to be reduced again or to energy losses from transformers.	**max 6**

	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 provides a description of the main features of the grid system which recognises that heating losses can be reduced by use of transformers to decrease the current. They should know that transformers require ac. They may not fully explain the reasoning for the use of a higher voltage and they are unlikely to refer to safety and insulation issues that require the voltage to be reduced again. **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 recognises that the use of higher voltage will reduce transmission losses and that transformers need ac. They give a much weaker account (if any) of the underlying principles. **Incorrect, inappropriate of no response: 0 marks** No answer or answer refers to unrelated, incorrect or inappropriate physics. **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.** voltages are changed using transformers, which work with ac but not with dc ac generation and transmission is therefore essential current in cables causes joule heating (or I^2R loss) resistance of cables should be as low as possible losses are reduced if current in cables can be reduced current can be reduced (for same power $I\ V$) if voltage is increased the higher the voltage, the smaller the proportion of the input power that is wasted high voltage introduces insulation problems and raises safety issues voltage must be reduced as the supply reaches its consumers this is done in stages as the supply is moved from overhead cables to underground wires transformers cause energy losses because they are not perfectly efficient features are incorporated in the design of transformers to reduce losses from them	
	Total	**13**

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