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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 2451
Specification A

PHYA4 Fields and Further Mechanics

Mark Scheme

2010 examination - January series

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 meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting 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 the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting 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 to download from the AQA Website: www.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**	
	C	B	D	A	D	B	B	A	A	D	B	D	A	
	14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**		
	C	B	C	C	D	B	D	D	C	B	A	A		

Section B

Question 1			
(a)		(grav) potential energy → kinetic energy → (grav) potential energy → kinetic energy → gravitational potential energy ✓ energy lost to surroundings in overcoming air resistance ✓	**2**
(b)	(i)	period $T = \left(\frac{42}{15}\right) = 2.8\,\text{s}$ ✓ use of $T = 2\pi\sqrt{\frac{l}{g}}$ gives length $l = \left(= \frac{T^2 g}{4\pi^2}\right) = \frac{2.8^2 \times 9.81}{4\pi^2}$ ✓ giving distance from pt of support to c of m, l = 1.9 (m) or 1.95 (m) ✓ answer must be to **2 or 3 sf** only ✓	**4**
(b)	(ii)	$E_k = mg\Delta h$ stated or used ✓ gives E_k of girl at lowest point = 18 × 9.81 × 0.25 = 44 (J) ✓	**2**
(b)	(iii)	$\frac{1}{2} mv^2 = 44.1$ gives max speed of girl $v = \sqrt{\frac{2 \times 44.1}{18}} = 2.2\,(\text{m s}^{-1})$ ✓ [**alternatively**: $A^2 = (3.9 - 0.25) \times 0.25$ gives $A = 0.955$ (m) and $v_{max} = 2\pi f A = (2\pi/2.8) \times 0.955 = 2.1\,(\text{m s}^{-1})$ ✓]	**1**
(c)		graph drawn on **Figure 2** which: shows $E_k = 0$ at $t = 0$, $T/2$ and T ✓ has 2 maxima of similar size (some attenuation allowed) at $T/4$ and $3T/4$ ✓ is of the correct general shape ✓	**3**
		Total	**12**

Question 2			
(a)	(i)	initial discharge current $\left(= \frac{V}{R} = \frac{6.0}{1.0 \times 10^5}\right)$ = 6.0×10^{-5} (A) ✓	**1**
(a)	(ii)	time constant is time for V to fall to (1/e) [or 0.368] of initial value ✓ pd falls to (6.0/e) = 2.21 V when t =time constant ✓ reading from graph gives time constant = 22 (± 1) ✓ unit: s ✓ (ΩF not acceptable) [**alternatively** accept solutions based on use of $V = V_0 e^{-t/RC}$ eg $1.5 = 6.0\, e^{-30/RC}$ ✓ gives $RC = \frac{30}{\ln(6.0/1.5)}$ ✓= 22 ✓ s✓]	**4**
(a)	(iii)	capacitance of capacitor $C = \left(\frac{\text{time constant}}{\text{R}} = \frac{22}{1.0 \times 10^5}\right)$ = 2.2×10^{-4} (F) = 220 (μF) ✓	**1**
(a)	(iv)	energy ∝ V^2 (or energy = ½ CV^2) ✓ ∴ $\frac{E_2}{E_1}$ = 0.10 gives = $\frac{V_2}{V_1}$ $(0.10)^{1/2}$ ✓ (= 0.316) ∴ V_2 = 0.316 × 6.0 = 1.90 (V) ✓ reading from graph gives V_2 = 1.90 V when t = 25 s ✓ [**alternatively** accept reverse argument: ie when t = 25 s, V_2 = 1.9 V from graph ✓ final energy stored = ½ × 2.2 × 10^{-4} × 1.9^2 = 3.97×10^{-4} (J) and initial energy stored = 3.96×10^{-3} (J) ✓ which is 10 × greater, so 90% of initial energy has been lost ✓] [**alternatively**, using exponential decay equation: use of $V = V_0 e^{-t/R}$ with t = 25 s and RC = 22 s gives V = 1.93 V ✓ energy ∝ V^2 (or energy = ½ CV^2) gives $\frac{E_2}{E_1} = \left(\frac{1.93}{6.0}\right)^2$ = 0.103 ✓ ∴ fraction of stored energy that is lost = $\frac{E_2 - E_1}{E_1} = 1 - \frac{E_2}{E_1}$ = 0.90 ✓]	**3**
(b)	(i)	initial energy stored is 4 × greater ✓ because energy ∝ V^2 (and V is doubled) ✓	**2**
(b)	(ii)	time to lose 90% of energy is unchanged because time constant is unchanged (or depends only on R and C) ✓	**1**
		Total	**12**

Question 3			
(a)	(i)	relationship between them is $E_p = mV$ (allow $\Delta E_p = m\Delta V$) [or V is energy per unit mass (or per kg)] ✓	**1**
(a)	(ii)	value of E_p is doubled ✓ value of V is unchanged ✓	**2**
(b)	(i)	use of $V = -\frac{GM}{r}$ gives $r_A = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{12.0 \times 10^{6}}$ ✓ $= 3.3(2) \times 10^{7}$ (m) ✓	**2**
(b)	(ii)	since $V \propto (-)\frac{1}{r}\left(or\ \frac{r_A}{r_B} = \frac{V_B}{V_A} = \frac{36.0}{12.0} = 3\right)$ $r_B = \frac{3.32 \times 10^{7} m}{3}$ ✓ (which is ≈ 1.1×10^{4} km)	**1**
(b)	(iii)	centripetal acceleration $g_B = \frac{GM}{{r_B}^2} = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(1.11 \times 10^{7})^2}$ ✓ [allow use of 1.1×10^{7} m from (b)(ii)] = 3.2 (m s^{-2}) ✓ [**alternatively**, since $g_B = (-)\frac{V_B}{V_a}$, $g_B = \frac{36.0 \times 10^{6}}{1.11 \times 10^{7}}$ ✓ = 3.2 (m s^{-2}) ✓]	**2**
(b)	(iv)	use of $\Delta E_p = m\Delta V$ gives $\Delta E_p = 330 \times (-12.0 - (-36.0)) \times 10^{6}$ ✓ (which is 7.9×10^{9} J or ≈ 8 GJ)	**1**
(c)		g is not constant over the distance involved (**or** g decreases as height increases **or** work done per metre decreases as height increases **or** field is radial and/or not uniform) ✓	**1**
		Total	**10**

Question 4		
(a) (i)	primary coil with more turns than secondary coil ✓ (wound around) a core **or** input is ac ✓	**2**
(a) (ii)	the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication	
QWC	**descriptor**	**mark range**
good - excellent	Two causes of energy losses are clearly identified, correct measures to indicate how these two losses may be reduced are stated and a detailed physical explanation of why these measures are effective is given. eg **any two** from the following four 1 When a transformer is in operation, there are ac currents in the primary and secondary coils. The coils have some resistance and the currents cause **heating of the coils**, causing some energy to be lost. This loss may be reduced by using **low resistance wire** for the coils. This is most important for the high current winding (the secondary coil of a step-down transformer). Thick copper wire is used for this winding, because thick wire of low resistivity has a low resistance. 2 The ac current in the primary coil magnetises, demagnetises and re-magnetises the core continuously in opposite directions. Energy is required both to **magnetise and to demagnetise the core** and this energy is wasted because it simply heats the core. The energy wasted may be reduced by choosing a material for the core which is easily magnetised and demagnetised, ie a **magnetically soft material** such as iron, or a special alloy, rather than steel. 3 The magnetic flux passing through the core is changing continuously. The metallic core is being cut by this flux and the continuous change of flux induces emfs in the core. In a continuous core these induced emfs cause currents known as **eddy currents**, which heat the core and cause energy to be wasted. The eddy current effect may be reduced by laminating the core instead of having a continuous solid core; the laminations are separated by very thin layers of insulator. Currents cannot flow in a conductor which is discontinuous (or which has a very high resistance). 4 If a transformer is to be efficient, as much as possible of the magnetic flux created by the primary current must pass through the secondary coil. This will not happen if these coils are widely separated from each other on the core. **Magnetic losses** may be reduced by adopting a design which has the two coils close together, eg by **better core design**, such as winding them on top of each other around the same part of a common core which also surrounds them.	**5 - 6**
modest - adequate	Up to two sources of energy losses are stated and there is an indication of how these may be minimised by suitable features or materials. There is no clear appreciation of an understanding of the physical principles to explain why these measures are effective.	**3 - 4**
poor - limited	Up to two sources of energy losses are given, but the answer shows no clear understanding of the measures required to minimise them.	**1 – 2**
incorrect, inappropriate or no response	There is no answer or the answer presented is irrelevant or incorrect.	**0**
	Answers which address only **one** acceptable energy loss should be marked using the same principles, but to max 3.	

(b)	(i)	power wasted internally (= $I\,V$) = 0.30 × 9.0 = 2.7 (W) ✓	**1**
(b)	(ii)	input power $\left(=\frac{2.7}{0.90}\right)$ = 3.0 (W) ✓ mains current $\left(=\frac{3.0}{230}\right)$ ✓ (= 1.30×10^{-2} A)	**2**
(b)	(iii)	energy wasted per year (= $P\,t$) = $3.0 \times 0.80 \times 3.15 \times 10^{7}$ = $7.5(6) \times 10^{7}$ (J) ✓	**1**
(b)	(iv)	energy wasted = $\frac{7.56 \times 10^{7}}{3.6 \times 10^{6}}$ = 21.0 (kWh) ✓ cost of wasted energy = 21.0 × 20 = 420p (£4.20) ✓	**2**
(c)		answers should refer to: an advantage of switching off ✓ • cost saving, saving essential fuel resources, reduced global warming etc a disadvantage of switching off ✓ • inconvenience of waiting, time taken for computer to reboot etc • risk of computer failure increased by repeated switching on and off • energy required to reboot may exceed energy saved by switching off	**2**
		Total	**16**