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General Certificate of Education (A-level)
January 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**	
	B	A	C	D	C	C	C	B	D	B	B	A	D	
	14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**		
	D	C	C	A	A	D	B	B	D	A	A	C		

Section B

Question 1		
(a)	$\omega \left(= \frac{2\pi}{T}\right) = \frac{2\pi}{97 \times 60}$ ✓ [or $\omega \left(= \frac{360}{T}\right) = \frac{360}{97 \times 60}$] $= 1.1 \times 10^{-3}$ (1.08×10^{-3}) ✓ [$= 6.2$ $(6.19) \times 10^{-2}$] rad s^{-1} [accept s^{-1}] ✓ [degree s^{-1}]	**3**
(b) (i)	$\frac{GMm}{r^2} = m\omega^2 r$ **or** $r^3 = \frac{GM}{\omega^2}$ ✓ gives $r^3 = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(1.08 \times 10^{-3})^2}$ ✓ $\therefore r = 6.99 \times 10^6$ (m) ✓	**3**
(b) (ii)	$F\ (= m\omega^2 r) = 1.1 \times 10^4 \times (1.08 \times 10^{-3})^2 \times 6.99 \times 10^6$ ✓ $= 9.0 \times 10^4$ (8.97×10^4) (N) ✓ [**or** $F\left(= \frac{GMm}{r^2}\right) = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times 1.1 \times 10^4}{(6.99 \times 10^6)^2}$ ✓ $= 9.0 \times 10^4$ (8.98×10^4) (N) ✓]	**2**
	Total	**8**

Question 2			
(a)		force = rate of change of momentum ✓	**1**
(b)	(i)	area under graph represents impulse **or change in** momentum ✓	**1**
(b)	(ii)	suitable method to estimate area under graph ✓✓ [eg counting squares: 20 to 23 squares ✓ each of area $25 \times 10^{-3} \times 20 = 0.5$ (N s) ✓ **or** approximate triangle etc ✓ ½ × 250 × 10^{-3} × 90 ✓] gives impulse = 11 ± 1 ✓ N s (or kg m s^{-1}) ✓	**4**
(b)	(iii)	use of impulse = Δ(*mv*) ✓ $\Delta p = mv - (-mu) = m(v + u)$ **or** $11 = 0.42(v + 10)$ ✓ giving $0.42v = 6.8$ and $v = 16$ (m s^{-1}) (impulse = 12 gives 19 m s^{-1}) ✓ answer to **2 sf** only ✓	**4**
(c)		final speed would be lower ✓ any **two** of the following points ✓✓ ● initial momentum would be greater [**or** greater *u* must be reversed] ● change in momentum [or velocity] is the same [**or** larger *F* acts for shorter *t*] ● initial and final momenta are (usually) in opposite directions ● initial and final momenta may be in same direction if initial speed is sufficiently high [**alternatively** final speed = $\frac{\text{impulse (from graph)}}{\text{mass of ball}}$ – initial speed ✓ gives final speed v = (26 ± 3) – initial speed u ✓ consequence is ● v is in opposite direction to u when $u < 26$ ● v is in same direction as u when $u > 26$ ● v is zero (ball stationary) when $u = 26$ any one of these bullet points ✓]	**3**
		Total	**13**

Question 3		
(a)	**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 the 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 sequence of releasing the ball and taking measurements of initial and final voltages. They should identify the correct distance measurement and show a good appreciation of how to use these measurements to calculate the time and acceleration from them. Time should be found from capacitor discharge, using known C and R values. Repeated readings would be expected in any answer worthy of full marks, but five marks may be awarded where repetition is omitted. **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 comprehensive and logical description of the sequence of releasing the ball and taking measurements of the initial and final voltages. They are likely to show some appreciation of the use of suvat equations to calculate the acceleration, although they may not recognise the need to measure a distance. **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 only be partly appropriate. The candidate is likely to have recognised that initial and final voltages should be measured, but may not appreciate the need for any other measurement. They may present few details of how to calculate the acceleration from the voltage measurements. **The explanation expected in a competent answer should include a coherent selection of the following points.** **Measurements** ● initial pd across C (V_0) from voltmeter (before releasing roller) ● distance s along slope between plungers ● final pd across C (V_1) from voltmeter ● measurements repeated to provide a more reliable result **Analysis** ● time t is found from $V_1 = V_0 e^{-t/RC}$, giving $t = RC \ln (V_0/V_1)$ ● from $s = ut + ½ at^2$ with $u = 0$, acceleration $a = 2s/t^2$ ● repeat and find average a from several results	**max 6**

(b)	(i)	$RC = 22 \times 10^{-6} \times 200 \times 10^{3}$ [or = 4.4 (s)] ✓ (4.40) $5.8 = 12.0\ e^{-t/4.40}$ ✓ gives $t = 4.40 \ln (12.0/5.8) = 3.2$ (3.20) (s) ✓	**3**
(b)	(ii)	$a\left(= \frac{2s}{t^2}\right) = \frac{2 \times 2.5}{3.20^2}$ ✓ = 0.49 (0.488) (m s^{-2}) ✓	**2**
		Total	**11**

Question 4			
(a)	(i)	$E\left(= \frac{V}{d}\right) = \frac{600}{80 \times 10^{-3}}$ ✓ $= 7.5 \times 10^{3}$ (V m^{-1}) ✓	**2**
(a)	(ii)	force F (= EQ) = $7500 \times 0.17 \times 10^{-6}$ ✓ (= 1.28×10^{-3} N)	**1**
(b)	(i)	correct labelled arrows placed on diagram to show the three forces acting; ● electric force F (or 1.3 mN) horizontally to left ✓ ● W (or mg) vertically down **and** ● tension T upwards along the thread ✓	**2**
(b)	(ii)	$F = T \sin\theta$ and $mg = T \cos\theta$ give $F = mg \tan\theta$ ✓ (or by triangle or parallelogram methods) $\tan\theta \left(= \frac{F}{mg}\right) = \frac{1.28 \times 10^{-3}}{4.8 \times 10^{-4} \times 9.81}$ (= 0.272) ✓ gives θ = 15(.2) (°) ✓	**3**
		Total	**8**

Question 5			
(a)	(i)	(vertically) downwards ✓	**1**
(a)	(ii)	force F is perpendicular to both B and I [**or** equivalent correct explanation using Fleming LHR] ✓ magnitude of F changes as size of current changes ✓ force acts in opposite direction when current reverses [**or** ac gives alternating force] ✓ continual reversal of ac means process is repeated ✓	**max 3**
(b)		appreciation that maximum force corresponds to peak current ✓ peak current = $2.4 \times \sqrt{2}$ = 3.39 (A) ✓ F_{max} (= $B\ I_{pk}\ L$) = 0.22 × 3.39 × 55 × 10^{-3} ✓ (= 4.10 × 10^{-2} N)	**3**
(c)		wavelength (λ) of waves $= \left(= \frac{c}{f}\right) = \frac{64}{80}$ = 0.80 (m) ✓ length of wire is $\lambda/2$ causing fundamental vibration ✓ [**or** λ of waves required for fundamental (= 2 × 0.40) = 0.80 m ✓ natural frequency of wire $\left(= \frac{c}{\lambda}\right) = \frac{64}{0.80}$ = 80 (Hz) ✓] wire resonates (at frequency of ac supply) [**or** a statement that fundamental frequency (or a natural frequency) of the wire is the same as applied frequency] ✓	**3**
		Total	**10**