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General Certificate of Education
June 2010

Physics A PHYA4

Fields and Further Mechanics

Unit 4

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 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**	
	B	C	D	D	D	C	A	B	A	A	B	D	A	
	14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**		
	A	B	D	A	C	A	C	B	B	D	C	C		

Section B

Question 1		
(a)	force of attraction between two point masses (or particles) ✓ proportional to product of masses ✓ inversely proportional to square of distance between them ✓ [**alternatively** quoting an equation, $F = \frac{GM_1M_2}{r^2}$ with all terms defined ✓ reference to point masses (or particles) **or** r is distance between centres ✓ F identified as an attractive force ✓]	**max 2**
(b) (i)	mass of larger sphere M_L (= $\frac{4}{3}\pi r^3\rho$) = $\frac{4}{3}$ π × (0.100)^3 × 11.3 × 10^3 ✓ = 47(.3) (kg) ✓ [**alternatively** use of $M \propto r^3$ gives $\frac{M_L}{0.74} = \left(\frac{100}{25}\right)^3$ ✓ (= 64) and M_L = 64 × 0.74 = 47(.4) (kg) ✓]	**2**
(b) (ii)	gravitational force F $\left(= \frac{GM_L{:}M_S}{x^2}\right) = \frac{6.67 \times 10^{-11} \times 47.3 \times 0.74}{0.125^2}$ ✓ = 1.5 × 10^{-7} (N) ✓	**2**
(c)	for the spheres, mass ∝ volume (or ∝ r^3, or $M = \frac{4}{3}\pi r^3\rho$) ✓ mass of either sphere would be 8 × greater (378 kg, 5.91 kg) ✓ this would make the force 64 × greater ✓ but separation would be doubled causing force to be 4 × smaller ✓ net effect would be to make the force (64/4) = 16 × greater ✓ (ie 2.38 × 10^{-6} N)	**max 4**
	Total	**10**

Question 2			
(a)	(i)	(vertically) downwards [**or** top to bottom, or down the page] ✓	**1**
(a)	(ii)	force on sphere F (= kx) = 0.24 × 18 × 10^{-3} ✓ (= 4.32 × 10^{-3} N)	**1**
(a)	(iii)	**use of** $F = EQ$ gives $E = \frac{4.32 \times 10^{-3}}{41 \times 10^{-9}}$ ✓ (= 1.05 × 10^{5} V m^{-1}) **use of** $E = \frac{V}{d}$ gives separation $d = \frac{5.0 \times 10^{3}}{1.05 \times 10^{5}}$ ✓ = 4.8 × 10^{-2} (m) ✓ (4.76 × 10^{-2})	**3**
(b)	(i)	electric field becomes zero (or ceases to exist) ✓ flow of charge (or electrons) from one plate to the other [**or** plates discharge] ✓ (until) pd across plates becomes zero [**or** no pd across plates, **or** plates at same potential] ✓	**max 2**
(b)	(ii)	net downward force on sphere (when E becomes zero) [**or** gravitational force acts on sphere, **or** force is weight] ✓ this force extends spring ✓ force (or acceleration) is proportional to (change in) extension of spring ✓ acceleration is in opposite direction to displacement (or towards equilibrium) ✓ for shm, acceleration ∝ (–) displacement [**or** for shm, force ∝ (–) displacement] ✓	**max 3**
		Total	**10**

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 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 momentum is conserved, supported by reasoning to explain why the conditions required for momentum conservation are satisfied in this case. The candidate also gives a statement that total energy is conserved, giving detailed consideration of the energy conversions which take place, described in the correct sequence, when there is an explosion on a body that is already moving. **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 states that momentum is conserved, but the reasoning is much more limited. **and/or** There is a statement that (total) energy is conserved, with basic understanding that some energy is released by the explosion. **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 indicates that either momentum or energy is conserved, or that both are conserved. There are very limited attempts to explain either of them.	**max 6**

	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. **Momentum** • momentum is conserved because there are no external forces acting on the overall system (probe plus capsule) – or because it's free space • they are moving in free space and are therefore so far from large masses that gravitational forces are negligible • during the explosion, there are equal and opposite forces acting between the probe and the capsule • these are internal forces that act within the overall system • because momentum has to be conserved, and it is a vector, the capsule must move along the original line of movement after the explosion **Energy** • total energy is always conserved in any physical process because energy can be neither created nor destroyed • however, energy may be converted from one form to another • the probe is already moving and has kinetic energy • in the explosion, some chemical energy is converted into kinetic energy (and some energy is lost in heating the surroundings) • the system of probe and capsule has more kinetic energy than the probe had originally, because some kinetic energy is released by the explosion	
(b) (i)	conservation of momentum gives $(500 \times 160) = 150\,v + (350 \times 240)$ ✓ from which $v = (-)26(.7)\,(\text{m s}^{-1})$ ✓ direction: opposite horizontal direction to larger fragment [**or** to the left, **or** backwards] ✓	**3**
(b) (ii)	initial $E_k = ½ \times 500 \times 160^2$ ✓ $(= 6.40 \times 10^6 \text{ J})$ final $E_k = (½ \times 350 \times 240^2) + (½ \times 150 \times 26.7^2)$ ✓ $(= 1.01 \times 10^7 \text{ J})$ energy released by explosion = final E_k – initial E_k ✓ $= 3.7 \times 10^6$ (J) ✓	**4**
	Total	**13**

Question 4			
(a)		magnetic field direction: $-z$ ✓	1
(b)		direction changes meaning that velocity is not constant ✓ acceleration involves change in velocity (or acceleration is rate of change of velocity) ✓ [**alternatively** magnetic force on electron acts perpendicular to its velocity ✓ ∴force changes direction of movement causing acceleration ✓]	2
(c)	(i)	$BQv = \frac{mv^2}{r}$ ✓ gives $v \left(= \frac{BQr}{m}\right)$ $= \frac{0.43 \times 10^{-3} \times 1.60 \times 10^{-19} \times 74 \times 10^{-3}}{9.11 \times 10^{-31}}$ ✓ (= 5.59×10^{6} m s^{-1})	2
(c)	(ii)	angular speed $\omega \left(= \frac{v}{r}\right) = \frac{5.59 \times 10^6}{74 \times 10^{-3}}$ = $7.5(5) \times 10^7$ ✓ *unit*: rad s^{-1} ✓ (accept s^{-1})	2
(c)	(iii)	frequency of electron's orbit $f \left(= \frac{\omega}{2\pi}\right) = \frac{7.55 \times 10^7}{2\pi}$ ✓ (= 1.20×10^7 s^{-1}) number of transits min^{-1} = $1.20 \times 10^7 \times 60 = 7.2 \times 10^8$ ✓ [**alternatively** orbital period $\left(= \frac{2\pi r}{v}\right) = \frac{2\pi \times 74 \times 10^{-3}}{5.59 \times 10^6}$ [**or** $\left(= \frac{2\pi}{\omega}\right) = \frac{2\pi}{7.55 \times 10^{-7}}$] ✓ (= 8.32×10^{-8} s) number of transits min^{-1} = $\frac{60}{8.32 \times 10^{-8}} = 7.2 \times 10^8$ ✓]	2
		Total	**9**

Question 5			
(a)		flux linkage $(= N\phi = BAN\cos\theta)$ $= 2.8 \times 10^{-2} \times 1.9 \times 10^{-3} \times 50 \times \cos 35°$ ✓ $= 2.2 \times 10^{-3}$ (Wb turns) ✓ answer must be to **2 sf** only ✓	**3**
(b)	(i)	reasonable sine curve drawn on axes, showing just one cycle, starting at emf = 0 ✓	**1**
(b)	(ii)	the flux linkage in these positions is **zero** ✓	**1**
(b)	(iii)	induced emf ∝ (or =) rate of change of flux (linkage) ✓ flux (linkage) through the coil changes as it is rotated ✓ from maximum at θ = 0, 180° to zero at 90° and 270° ✓ rate of change is greatest when plane of coil is parallel to B [**or** reference to $\varepsilon = BAN\omega \sin \omega t$, **or** $\varepsilon = BAN\omega \sin \theta$] ✓ because coil then cuts flux lines perpendicularly [**or** $\varepsilon = BAN\omega \sin \omega t$ shows ε is greatest when ωt = 90° or 270°] ✓	**max 3**
		Total	**8**