OXFORD
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INTERNATIONAL A-LEVEL

PHYSICS

PH03

Unit 3 Fields and their consequences

Mark scheme

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221XPH03/MS

Mark schemes are prepared by the Lead Assessment Writer 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 associates 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 associate understands and applies it in the same correct way. As preparation for standardisation each associate 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, associates encounter unusual answers which have not been raised they are required to refer these to the Lead 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 oxfordaqaexams.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	Evidence of use of $\omega = \frac{2\pi}{T}$ ✓ (to determine ω) Maximum kinetic energy read from graph ✓ Evidence of use of $E_k = \frac{1}{2} m v^2$ And $v_{max} = \omega A$ ✓ To give $A = 25$ mm ✓	Expect to see $\frac{2\pi}{0.68}$ or 9.2 rad s^{-1} Expect an answer that rounds to 9.4 ($\times 10^{-4}$ J) For MP3 the substitution or correct evaluation must be seen Expect to see 0.23 (m s^{-1}) Give full credit for combined equations	4	1 × AO1 3 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Horizontal line between +/- $\frac{A}{2}$ ✓ at 0.235 mJ ✓	If MP1 is not given, MP2 can be given if the **maximum** of the line is at 0.235 mJ Allow answer greater than 0.22 and less than or equal to 0.24	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Use of $mg = ke$ to determine k, or seen in formula for T AND Use of $T = 2\pi\sqrt{\frac{m}{k}}$ ✓ to give $T = 0.41$ s ✓	Expect to see $k = 8.2$ (N m^{-1}) Accept use of $T = 2\pi\sqrt{\frac{e}{g}}$ provided *e* is explicitly the extension At least 2 sf	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Use of $\omega = \frac{2\pi}{T}$ or seen in formula for v ✓ Use of $v = \pm\,\omega\sqrt{A^2 - x^2}$ With $A = 5.0 \times 10^{-2}$ (m) **or** $x = 4.2 \times 10^{-2}$ (m) ✓ To give $v = 0.41$ (m s^{-1}) ✓ OR Alternative calculation using energy: calculation of EPE at bottom (1.58×10^{-2} J)✓ calculation of GPE at top (3.16×10^{-2} J) ✓ calculation of v from difference (KE) ✓	Expect to see $\omega = 15.3$ (rad s^{-1}) Or 15.7 if 0.4 used for T If $x = 0$ seen, award max 2 Allow POT error in substitution Accept 0.42(6) from rounding Give full credit for use of $x = A\cos(wt)$ (MP2) And $v = Aw\cos(wt)$ and answer (MP3)	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	(After extension becomes zero) force is constant, so acceleration is constant (so no longer SHM) ✓ acceleration is no longer proportional to (-) displacement ✓	Alternatives for MP1 • Force (on the load) is equal to the weight • The acceleration (of the load) is g Treat suggestion that acceleration no longer opposite to displacement as neutral	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
01.6	Period of X is greater than period of Y and mass is the same ✓ discussion involving $T = 2\pi\sqrt{\frac{m}{k}}$ So stiffness of Y must be greater. ✓ OR Calculation of one stiffness. ✓ Calculation of other stiffness and correct comparison. ✓	Answer suggesting X has greater stiffness gets zero marks. Relationship between T, m, k may be expressed qualitatively For X stiffness = 3.0 (Nm^{-1}) For Y stiffness = 8.2 (Nm^{-1})	2	AO2
Total			**15**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Evidence of use of $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ (to give λ) ✓ Use of $A = \lambda N$ (To give A) ✓ Comparison of activity of water with maximum allowed activity AND answer 'water is safe to drink' ✓	Expect to see 1.79×10^{-9} (s^{-1}) or 0.056 (yr^{-1}) Expect to see 19.6 (Bq) or 7.9×10^4 (Bq m^{-3}) Do not award MP2 if unit is yr^{-1} Accept alternatives for MP3 e.g. Limit in 2.5×10^{-4} m^3 $= 7.6 \times 10^7 \times 2.5 \times 10^{-4} = 1.9 \times 10^4$ This is greater than A, so water is safe to drink. OR Activity in 1 m^3 = $A/2.5 \times 10^{-4}$ $= 7.9 \times 10^4$ (Bq) Which is less than 7.6×10^7 so water is safe to drink Allow rounding errors	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	150 years is (approximately) 12 half lives OR calculation of fraction of initial count rate ✓ Activity/amount of tritium = 2.4×10^{-4} times initial value So activity/amount of tritium may be too low to detect ✓	Evidence for MP1 may be seen in MP2 For MP2 expect to see determination of effect of 12 half-lives. Allow 2.1×10^{-4}	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Evidence of use of $N = N_0 e^{-\lambda t}$ ✓ To give $t = 1.7 \times 10^5$ yr ✓	Award MP1 for rearrangement or substitution Condone POT error in MP1	2	AO2
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	(Reference to Fleming's left-hand rule) Identification that current in slide is towards X and magnetic field is up ✓	Current direction can be drawn on Figure 5	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	(Evidence of use of $F = BIl$) to give 4.8×10^6 A ✓	Must show some working by either rearrangement or substitution At least 2 sf	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Evidence of use of work done = force × distance ✓ Evidence of use of GPE gained = mgh ✓ KE = work done – GPE gained ✓ Use of their KE = ½ mv^2 to determine v ✓	Expect to see 4.5 (× 10^9 J) Expect to see 1.0(4) (× 10^5 J) Do not award MP3 if answer suggests work done = KE gained with no ref to GPE e.g. GPE is negligible Expect to see 8.5×10^3 (m s^{-1})	4	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	(doubling rail length) doubles work done on slide and rocket ✓ increasing speed by a factor of (approximately) $\sqrt{2}$ ✓	Condone 'doubles the KE of slide' Allow answer in terms of their value from **03.3**	2	1 × AO3 1 × AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	Doubling current also doubles B✓ Force on/work done on of slide and rocket increases by a factor of 4 therefore speed is increased by a factor of (approximately) 2 ✓	Allow in terms of their value from **03.3** Condone 'KE increases by factor of 4' in MP2	2	1 × AO3 1 × AO4
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Correct substitution of Q and r into $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ ✓ To give 5.8×10^{-9} (N) ✓	Allow POT errors in substitution Correct answer gets both marks.	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Evidence of use of potential at a point $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$ Or potential energy equation ✓ Attempt to calculate potential energy difference = (their ΔV x Q) ✓ 1.2×10^{-10} (J) ✓	For MP1 expect to see calculation of • Potential at 1.5 mm for one of the charges (7.2 V) Or • Potential energy of charges at 1.5 mm separation (8.6×10^{-12} J) Or • Potential at 101×10^{-6} m for one of the charges (107 V) • Or • Potential energy of charges at 101×10^{-6} m separation (1.3×10^{-10} J) Potential difference (ΔV) = 100 V Condone POT errors in MP1 and MP2 Do not credit use of work done = force × distance	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	(vertically) down ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Evidence of calculation of weight of droplet ✓ Use of $F = EQ$ ✓ To give $E = 6.4(5) \times 10^{3}$ (V m^{-1}) ✓	Expect to see $F = mg = 1.38 \times 10^{-9} \times 9.81 = 1.35 \times 10^{-8}$ (N) MP2 can be given for substitution or rearrangement. Allow ecf for their F Condone minus sign in final answer	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Calculation of area ✓ evidence of $C = \frac{A\varepsilon_0\varepsilon_r}{d}$ to give 1.55×10^{-7} F ✓	Expect to see 5.9×10^{6} m^{2} At least 3 sf	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.6	Use of energy stored = $\frac{Q^2}{2C}$ ✓ 2.4×10^{10} (J) ✓	Allow ecf from 4.5 Show that value gives 2.5×10^{10} (J)	2	AO2
Total			**13**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Evidence of use of $g = \frac{GM}{r^2}$ ✓ To give $1.45\ (\text{m s}^{-2})$ ✓	Condone POT error in substitution	2	2 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Use of $\omega = \sqrt{\frac{GM}{r^3}}$ and $T = \frac{2\pi}{\omega}$ ✓ To give 7.1×10^3 (s) ✓	Alternative: use of $a = \omega^2 r$ and $T = \frac{2\pi}{\omega}$ ✓ Allow ecf for their a in **5.1** to calculate T ✓ In MP1 condone one substitution error for M or r.	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Use of GPE = mV (to calculate V) ✓ Use of gravitational potential $V = \frac{GM}{r}$ ✓ To give 4.7×10^4 (m) ✓	Expect to see $r = 1.78 \times 10^6$ m Condone 4.3 x10^4 (m) if rounded value of r used	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Calculation of KE in orbit OR calculation of GPE on surface of Moon ✓ Evidence of (KE + GPE) in orbit – (GPE on surface of moon) ✓ To give 1.83×10^8 J ✓	Expect to see 1.74 ($\times 10^8$ J) Expect to see (-)3.56 ($\times 10^8$ J)	3	AO2

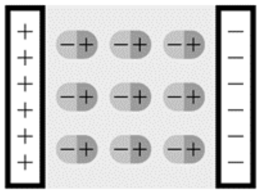
Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	Relates gravitational field strength to centripetal acceleration. ✓ Identifies that increase (local) density increases gravitational field strength (and therefore increases centripetal acceleration) ✓	MP2 could be argued from reduction in distance to centre of mass of Moon If no other mark awarded allow an application of Newton's 2nd Law of motion.	2	AO3
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	There is an increase/change in the magnetic flux linkage with the coil.✓ Reference to Faraday's Law.✓	Do not accept 'increase in rate of change of flux linkage'	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	(Ref to Lenz's Law) Emf is induced in direction to oppose changing flux linkage as magnet enters/leaves coil.✓ Flux linkage increasing and decreasing are opposite effects (so emfs must have opposite signs) ✓	Condone 'flux' for 'flux linkage'	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Magnet is going slower when entering ✓ Smaller rate of change of flux linkage ✓ (Therefore smaller induced emf) (Reference to Faraday's Law)	Argument can be made for V_1 smaller or V_2 greater.	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Magnet is accelerating downwards ✓ Time from top of coil to centre of coil is greater than time from centre to bottom of coil. ✓ Emf is zero when magnet is at the centre of the coil.✓		Max 2	AO4
Total			**8**	

Question	Key	Answer	AO
07	**D**	kg A^{-1} s^{-2}	AO1
08	**C**	0.84 A	AO1
09	**A**	$\frac{BQv}{m}$	AO1
10	**A**	circular, curving upwards	AO2
11	**B**	$\frac{N\Phi}{t_2}$	AO1
12	**D**	86%	AO2
13	**A**	0.1 2	AO2
14	**B**	electric field magnitude of charge on **Y** > magnitude of charge on **X**	AO1
15	**C**	 increases	AO1
16	**C**	They increase if the peak current in the secondary coil increases.	AO1
17	**B**	At time $\frac{T}{2}$ the potential energy E_p of the particle is a minimum.	AO1
18	**B**	290	AO2
19	**D**	$r \propto \frac{1}{v^2}$	AO1

20	**D**	59 MPa	AO2
21	**C**	4.9 N kg^{-1}	AO2