OXFORD
INTERNATIONAL
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INTERNATIONAL A-LEVEL
PHYSICS
PH03
Unit 3 Fields and their consequences

Mark scheme

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231XPH03/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	Arrow drawn from water towards **X** ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Idea that reaction force $= 0$ N	Treat consideration of the tension as neutral.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Evidence of weight = mass x centripetal acceleration ✓ (To give) evidence of $\omega = \sqrt{\frac{g}{r}}$ ✓ $= 3.4(0)$ (rad s^{-1}) ✓	e.g. $mg = mr\omega^2$ For MP2 credit either manipulation or substitution Note: ans= 3.39723 using g = 9.81 ans=3.39550 using g = 9.8	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Idea of reducing mass of water ✓ …reference to (Max $T =$) $mg + mr\omega^2$ ✓ Idea of reducing radius of circle ✓ …reference to $mr\omega^2$ ✓	If no reference to mg in the discussion, do not award MP2	4	AO3
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Graph is straight line AND line goes through origin acceleration = constant × displacement OR acceleration and displacement are directly proportional ✓ Graph has negative gradient idea that the constant of proportionality is negative OR acceleration and displacement are in opposite directions ✓	Condone missing 'directly'	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Value of acceleration and displacement read from graph ✓ Use of $a = -\omega^2 x$ and $\omega = 2\pi f$ OR $a = -(2\pi f)^2 x$✓ To give $f = 660$ (Hz) ✓	Accept any point on line or gradient calculation Eg displacement = 1×10^{-3} (m) and acceleration = -17.2×10^3 (m s^{-2}) Do not condone PoT error in MP1 Expect to see 4.2 ($\times 10^3$) for ω Accept answers that round to 660 or 670	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Use of $v_{max} = A\omega$ OR $v_{max} = 2\pi f A$ with $A = 1$ mm OR their ω OR their f or 700 (Hz) ✓ to give $v = 4.2$ m s^{-1} ✓	Condone PoT error in MP1 Look for $\omega = 4.2 \times 10^3$ rad s^{-1} Use of show that value of 700 Hz gives 4.4	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	**P** at $(0,0)$ ✓	Answer must be marked on graph	1	AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Suggestion is incorrect as Area between a and **X** >> area between **X** and b OR Idea that electric field is not uniform OR -1.5 kV would be potential at midpoint in a uniform field ✓ (Difference in) potential /ΔV is area under graph (of E against r) ✓	No marks awarded if answer states suggestion is correct. Allow idea that more than half the area is between a and **X** Treat references to radial field as neutral Accept for MP2 for (idea that) $E = (-)\frac{\Delta V}{\Delta r}$	2	1 x AO1 1 x AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Evidence of use of $F = ma$ OR $2.7 \times 10^{-17} \times 91$ seen ✓ Evidence of their $F = EQ$ ✓ $E = 7.7 \times 10^{3}$ (N C^{-1}) ✓	Expect to see 2.5×10^{-15} (N) Condone missing signs	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	(Figure 6 shows) field strength decreases (away from rod) so (horizontal) force on particle decreases ✓ (horizontal component of) acceleration decreases ✓ Direction of force does not change so direction of acceleration does not change ✓	If no other mark is awarded, one mark can be given for idea that vertical component of acceleration is zero 2	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Use of work done = VQ OR (–) $3000 \times$ (–) 3.2×10^{-19} seen ✓$_1$ Initial KE = $\frac{1}{2} mv^2$ $= 3.6 \times 10^{-16}$ J✓$_2$ Calculation of their work done + their initial KE ✓$_3$ (Use of ½ mv^2 to give) $v = 9.9$ m s^{-1} ✓$_4$	Expect 9.6×10^{-16} J Expect to see 1.32×10^{-15} J	4	AO3
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Evidence of use of $R = V/I$ $= 1.6 \times 10^4\ \Omega$ ✓	$R = 6/3.8 \times 10^{-4}$ Calculator gives 1.578947×10^4	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Idea that the pd across capacitor increases therefore pd across variable resistor must decrease ✓ (So R must decrease to maintain constant I)		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	$Q = It$ or equivalent seen To give $Q = 3.8 \times 10^{-4} \times 120$ $= 0.0456$ (C) ✓	Do not accept 2 sf answer Working must be seen	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Reading from graph to obtain V after $120\ \text{s}$ AND Use of $C = \frac{Q}{V}$ = their answer to **04.3** divided by their V ✓ To give $8.1 \times 10^{-3}\ \text{F}$ ✓	Accept $5.5\ \text{V}$ to $5.7\ \text{V}$ The second mark is a quality mark. Accept 8.0 to 8.3 Allow use of $0.046\ \text{C}$ to give 8.1 to $8.4 \times 10^{-3}\ \text{F}$ Alternative using $C = \frac{current}{gradient}$. MP1 for determination of gradient using at least half of the line. MP2 for final answer in range.	2	1 × AO1 1 × AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Use of $C = \frac{\varepsilon_0 \varepsilon_r A}{d}$ ✓ (To give $\varepsilon_r = 0.13 \times 10^{-9} \times 3.5 \times 10^{-3} / (8.85 \times 10^{-12} \times 0.15^2)$) $= 2.3$ ✓	Either for substitution or manipulation Condone PoT in MP1	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.6	Idea that the capacitance is too small/ much lower (than original)✓ No because: Charge stored too small/much less (at the same pd) ✓ Current would become zero too quickly to take readings (with a stop watch) OR pd across capacitor would reach 6.0 V too quickly to take readings (with a stop watch) ✓	Alternative: For MP1 makes use of capacitance in a valid equation without PoT error✓ For MP2 determines the charge stored✓ For MP3 determines the time and makes suitable comment. ✓ Alternatives for MP3 idea that pd changes too quickly for the current to be kept constant by adjusting the variable resistor. Alternative for MAX 2 Yes but: Would need much larger resistance ✓ Must have a much more sensitive ammeter ✓	3	AO4
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Time taken for activity/mass (of fluorine-18) OR number of atoms/nuclei (in fluorine-18) to decrease by half ✓	Accept 'amount' Condone 'particles'	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	$T_{½} = \ln 2/\lambda$ seen and used $\lambda = 1.05 \times 10^{-4}$ ✓	Do not accept less than 3 sf answer	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Uses $A = \lambda N$ ✓ (to determine N) Use mass = N × atomic mass/N_A ✓ to give mass = 1.1×10^{-13} kg ✓	Expect to see $N = 3.52 \times 10^{12}$ Allow ecf for their value of λ Use of 1.1×10^{-4} gives 1.01×10^{-13} kg	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Uses $A = A_0e^{-\lambda t}$ ✓ to get $A_0 = 3.5 \times 10^{10}$ Bq ✓	Allow ecf for their value of λ Use of 1.1×10^{-4} gives 4.3×10^{10} Bq	2	AO2
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	(the particle) moves parallel to the field (line) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Uses perpendicular velocity (4.5×10^{5} ms^{-1}) AND uses $F = BQv$ ✓ (to get F) Uses their $F = mv^2/r$ ✓ To get $r = 3.9 \times 10^4$ m ✓	Expect to see 8.6×10^{-21} N Accept use of mv/BQ as evidence of use of equation in MP1 and MP2 Allow ecf for v in MP2	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	(Helix because:) Parallel component of velocity unaffected (by magnetic field) OR (Magnetic) force on particle is perpendicular to its (instantaneous) velocity ✓ So the force is centripetal /the force causes circular motion ✓	Alternative: Clockwise because: Proton motion is in direction of conventional current ✓ Reference to Fleming's LHR ✓	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Refers to emf and rate of change of flux linkage. ✓ High emf achieved by: Rapid (rate of) change (of flux density) owtte ✓ Very large (linked) area as power cables are very long ✓		3	AO3
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	$F = G\frac{m_1 m_2}{r^2}$ seen and used To give $F = 3.88 \times 10^{12}$ N ✓	Condone use of r = distance to Sun + radius of Sun to give 3.82×10^{12} N Calculator gives 3.879758×10^{12}	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	(For circular motion, $F = \frac{mv^2}{r}$) Determines $\frac{mv^2}{r}$ for comet ✓ indicates that this is not equal to force from **07.1** ✓	Expect to see $7.62(3) \times 10^{12}$ Allow similar calculations to show that one of r, v or d is not consistent with circular motion. Attempt to show m not correct should be given no credit.	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Using 1 year for T and 1 Earth orbital distance for R $k = 1$ ✓ So $T^2 = k(18)^3$ ✓ $T = 76$ years ✓	Accept alternative values for k based on Earth orbit Accept missing k in MP2 Alternative using simultaneous equations MP1 equation applied to earth and comet e.g. $T_E{}^2 = kR_E{}^3$ $T_C{}^2 = kR_C{}^3$ OR $T_C{}^2 = k(18R_E)^3$ MP2 combines to remove k MP3 correct answer	3	2 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Calculates KE using ½mv^2 OR Calculates GPE using $-G\frac{m_1m_2}{r}$ OR Attempts to add KE and GPE numerically or algebraically✓ To give -6.0×10^{21} J ✓	Expect to see 3.338×10^{23} J Expect to see -3.398×10^{23} J	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.5	Suggestion is correct Maximum/at infinity GPE is zero ✓ Idea that KE is greater than the energy needed to reach infinity/escape ✓	For MP2 allow idea that KE is greater than the magnitude of GPE	2	AO3
Total			10	

Question	Key	Answer	AO
8	**C**	1.09 m	AO1
9	**B**	E E	AO1
10	**C**	9	AO2
11	**D**	$\frac{3g}{2\pi dG}$	AO2
12	**D**	from **X** to **S**	AO1
13	**A**	increases stays the same	AO1
14	**D**	current in **R** potential difference across **P**	AO3
15	**B**	15 s	AO2
16	**C**	120 mJ	AO1
17	**A**	0.036 N down	AO2
18	**C**	0.033 Wb	AO2
19	**B**	150 W	AO2
20	**C**	2.0 A	AO2
21	**B**	0.6 m	AO2
22	**A**	$\left(\frac{1}{f\Delta L}\right)^2$	AO2