OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL

PHYSICS

PH03

Unit 3 Fields and their consequences

Mark scheme

January 2025

Version: 1.0 Final

2 5 1 X P H 0 3 / M S

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	Use of trig approach ✓ 4.9(4) (m) ✓	eg $2 \times 67.7 \times \sin(2.09)$ Condone $67.7 \times \sin(4.18)$ **alternative** converting to radians ✓ use of $d \approx r\theta$ to give answer ✓ accept 4.93 (m)	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Use of $T = 2\pi\sqrt{\frac{l}{g}}$ and $T = \frac{2\pi}{\omega}$ ✓ Use of $\frac{1}{2}m\omega^2A^2 = \frac{1}{2}mv^2$ OR $v = \textit{their}\,A \times \textit{their}\,\omega$ ✓ $0.94\ (\text{m s}^{-1})$ ✓	"Use of" means by substitution or rearrangement Look for $T = 16.5\ \text{s}$ For mp1 look for $\omega = \sqrt{\frac{g}{l}}$ Allow ecf for their 1.1 . Do not accept $67.7\ \text{m}$ for their A. Note $A = 4.9$ gives 0.93 ms^{-1} Alternative MP1 and MP2: Any two from: ✓✓ • $67.7 \times \cos(2.09)$ seen • height above ground $= 67.7\ (\text{m})$ – calculated length seen • attempt to use $v = \sqrt{2gh}$ OR $mgh = ½\ mv^2$	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	evidence of determination of circumference of path OR use of their path length ÷ number of seconds in one day ✓ 304 (m s^{-1}) ✓	Expect to see 2.63×10^7 (m) For MP1 accept alternative using $\omega = \frac{2\pi}{T}$ OR $v = r\omega$ with their ω Accept 305 or 300 (m s^{-1})	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Two from: ✓✓ • calculation of period (16.5 (s)) • their angle from $360°$ × their period divided by 31.8 hours • evidence of $22.5°$ divided by their angle 433 or 434 or 430 ✓	Allow ecf from **01.2** if T calculated. Alternative route for MP1 and MP2 Two from: • calculates period • calculates time to move $22.5°$ (7155 s) • divides their time by their period condone answer that is not a whole number but rounds to 433 or 434	3	AO2

Total			**10**

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Attempt to use $F = G\frac{m_1 m_2}{r^2}$ ✓ 120 (N) ✓	Require to see at least mass of B and either r^2 for mp1. Condone POT errors. Correct answer gets both marks. Accept answer that rounds to 120 to 3 sf OR 120.5 NOTE answer using incorrect r =11.3 (N) gets 1 mark	2	1 × AO3 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Any two from: ✓✓ • $E_p = (-)G\frac{m_1 m_2}{r}$ seen • evidence of $E_k = -1.19 \times 10^{12}$ – their E_p • attempts to use ½ mv^2 = their E_k 2.1×10^4 (m s^{-1}) ✓	Condone missing or incorrect minus signs in mp1 and mp2. Do not reward equations based on a circular orbit	3	2 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	gravitational force = mass × centripetal acceleration seen in some form OR Evidence of $\omega = \frac{2\pi}{T}$ OR $v = r\omega$ in an expression for centripetal acceleration✓$_1$ $r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$ ✓$_1$ ✓$_2$ 8.9×10^{10} (m) ✓$_3$	Award mp1 and mp2 for correct radius equation seen For MP2 accept $4\pi^2 r^3 = GMT^2$ in any form	3	1 × AO3 1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Idea that the (gravitational) potential (energy of the spacecraft) is constant on an equipotential surface so that **B** is not on an equipotential as its radius changes OR **C** is on an equipotential surface as its radius is constant.	Idea can be inferred Accept idea that in a circular orbit the gravitational force is at right angles to the motion of satellite so no work is done.	1	AO1

Total			**9**

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Use of $\frac{1}{2} mv^2$ OR Idea that eV = their kinetic energy ✓ 620 or 623 or 624 (V) ✓	Accept 1.6×10^{-19} for e Accept more than 3sf answer that rounds to 623 or 624 Accept 622 using an e/m approach	2	1 × AO3 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Acceleration is constant / acceleration is (vertically) downwards ✓ Electric field is uniform/constant therefore the force on the electron is constant ✓ Idea that the force is downwards because the electron is negative OR that the force is downwards as it is in the opposite direction to the field.✓	"Towards V_2/bottom plate" is not enough for "downwards".	3	1 × AO3 2 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Evidence of 0.120 m divided by 1.48×10^7 m s^{-1} to give 8.1×10^{-9} s ✓	At least 2 sf	1	AO2

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>03.4</td><td>Three from: ✓✓✓
• determines the vertical displacement = 27 ± 1 (mm)
• uses suvat with their displacement and time from 03.3 to find acceleration
• uses $F =$ their acceleration × mass of electron
• uses their $F = \frac{V_2 e}{0.07}$

Answer 328 OR 330 (V) ✓</td><td>Alternative correct answers:<table><tr><td></td><td>8.1 ns</td><td>8.0 ns</td></tr><tr><td>26 mm</td><td>316 (V)</td><td>324 (V)</td></tr><tr><td>28 mm</td><td>340 (V)</td><td>349 (V)</td></tr></table>Allow third bullet point for combining F = ma with F=Eq or $F = \frac{Vq}{d}$
“Show that” value gives 336 or 340 V</td><td>4</td><td>2 × AO3
2 × AO2</td></tr>
</table>

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>03.5</td><td>Two from: ✓✓
• idea that the paths are broader as there is a range of electron speeds due to collisions with air particles
• idea that the paths are fainter as some electrons do not reach the screen
• idea that the paths bend more / y is greater as electrons are slower / so spend more time (accelerating)</td><td>Allow idea that the path is broader as electrons are scattered by collisions.</td><td>2</td><td>AO4</td></tr>
</table>

<table>
<tr><td>Total</td><td></td><td></td><td>12</td></tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	(use of intercept to give) $6.2+/-0.05$ (V) ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Evidence of attempt to use $R = V \div I$ ✓ 6.5×10^3 (Ω) ✓	For mp1 expect to see $-1\times$ gradient or $\frac{\varepsilon - V_c}{I}$ for one point or $\varepsilon \div I$-intercept For MP2 accept 6.3×10^3 to 6.7×10^3	2	1 × AO1 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Idea that smaller current means less charge moved per second (and therefore smaller increase in V_c per second)	Accept use of charging equation and idea that rate of change of voltage decreases.	1	AO2

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>04.4</td>
<td>Uses pair of current points OR emf and V point✓

Uses appropriate time between points ✓

Substitutes into charging equation for current or voltage ✓

(time constant =) 1.4×10^{-2} (s) based on correct working ✓

Use of time constant = their answer to 04.2 × C
($C = 2.2 \times 10^{-6}$ (F)) ✓</td>
<td>In MP1 condone use of any two V points
Allow half-life approach NEW MS
Allow 1.3 x 10^{-2} to 1.5 x 10^{-2} for MP4
In MP3 V_o must be the emf:
$V = V_o(1 - e^{-\frac{t}{RC}})$ OR $I = I_o e^{-\frac{t}{RC}}$

<table>
<tr><td>I/mA</td><td>V/V</td></tr>
<tr><td>0.95</td><td>0.00</td></tr>
<tr><td>0.67</td><td>1.83</td></tr>
<tr><td>0.47</td><td>3.12</td></tr>
<tr><td>0.33</td><td>4.03</td></tr>
<tr><td>0.24</td><td>4.67</td></tr>
<tr><td>0.17</td><td>5.12</td></tr>
<tr><td>0.12</td><td>5.46</td></tr>
<tr><td>0.08</td><td>5.66</td></tr>
<tr><td>0.06</td><td>5.82</td></tr>
<tr><td>0.04</td><td>5.93</td></tr>
</table>

Credit 1/e or ‘half-life’ approach for MP1, MP2, MP3 e.g.
Uses .6.2 V and 3.1 V✓
Uses $T_{½}$= 2 × 5 ms✓
Uses time constant = $\frac{T_{½}}{ln2}$✓</td>
<td>5</td>
<td>3 × AO3
2 × AO2</td>
</tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Straight line from origin ✓ Ending at $(0.95, 6.2)$ ✓	Allow half a grid square Allow ecf from their **Figure 7**. If line not drawn in **Figure 7** allow ecf from 04.1	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.6	Idea that the time interval (5 ms) is too short for the ammeter and voltmeter readings to be recorded manually ✓		1	AO4

Total			**12**

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Two from ✓✓ • determines decay constant = 4.18×10^{-9} s^{-1} • $N = 62$ (kBq) ÷ their decay constant • mass = $60 \times$ their $N \div 6.02 \times 10^{23}$ 1.48×10^{-9} (g) ✓	 Allow 2 sf answer	3	1 × AO3 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Attempts to use $A = A_0 e^{-\text{their } \lambda t}$ ✓ Correct use of $\log_e$ ✓ 15(years) ✓	Allow ecf for their λ	3	1 × AO1 2 × AO2

Total			**6**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Flux density of a flux of $1\ \text{Wb}$ passing through an area of $1\ \text{m}^2$ ✓	Allow: Flux density that produces a force of $1\ \text{N}$: per metre of wire carrying a current of $1\ \text{A}$ at right angles to magnetic field OR on a particle with a charge of $1\ \text{C}$ moving with a velocity of $1\ \text{m s}^{-1}$ at right angles to magnetic field condone 'unit' for values of current, force, charge, length, area	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Reference to Fleming's left-hand rule and idea that therefore the current is into the page. ✓ + sign on right-hand socket of power supply. ✓	For mp1 accept arrow on the rod with explanation. Allow ecf in MP2 if current direction is clear.	2	1 × AO3 1 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Two from: ✓✓ • evidence of $F = BIl$ or $F = 0.025$ (N)) • use of $mg \sin(10^o)$ or equivalent • use of weight or component of weight = BIl 0.015 (kg) ✓	in third bullet point allow use of mg, or $mg \cos(10^o)$ or $mg \sin(80^o)$ for component of weight.	3	1 × AO1 1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Idea that emf increases because the rate of flux linkage increases (as rod accelerates) ✓ emf is directly proportional to rate of change of flux (linkage) OR refers to Faraday's law and a change in flux (linkage) ✓	Allow flux cutting for flux linkage. Condone 'field lines' for (magnetic) flux Allow "equal to" for "directly proportional" Evidence of flux linkage for MP2 can be seen in MP1.	2	1 × AO1 1 × AO2

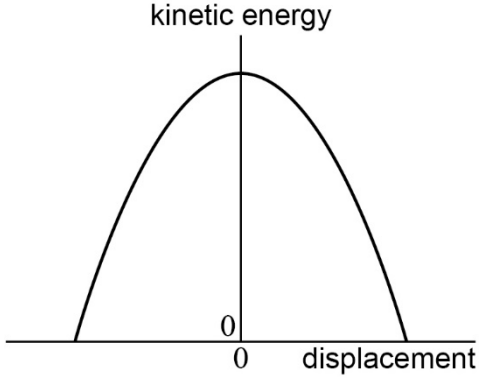
Total			**8**

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Max 3 from: ✓✓✓ • recognises that the peak voltage is $12.0 \times \sqrt{2}$ • recognises that periodic time is $\frac{1}{60}$s • y-gain = their peak ÷ 3.4 (V cm^{-1}) (= 5) • time base = their period ÷ 6.67 (= 2.5) 5 and 2.5 both correct ✓	Expect to see 16.97 V	4	1 × AO2 3 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	18 000 (turns)		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	(rms/peak) primary current AND (rms/peak) secondary current or resistance of resistor ✓	Allow answers that refer to joulemeter and stopwatch	1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Two from: ✓✓ • idea of eddy currents (in core) • idea of magnetic field escaping (from core) • idea of (Ohmic) heating in wires/coil	Accept answers that discuss hysteresis effects	2	AO1
Total			**8**	

Question	Key	Answer	AO
08	**B**	2.6 N	AO2
09	**C**	0.42 rad s^{-1}	AO2
10	**C**	$\frac{a}{Bv}$	AO2
11	**D**		AO2
12	**A**	$\frac{GM\Delta r}{R^2}$	AO2
13	**D**	decreases decreases	AO1
14	**C**	38 mJ	AO2
15	**D**	$-\frac{Q_1}{R \times \text{gradient at } (t_1, Q_1)}$	AO1
16	**B**	0.49 m	AO2

17	**B**	$\frac{V}{2}$ $\frac{E}{4}$	AO1
18	**A**	gravitational field strength electric potential	AO1
19	**C**	3.6×10^4 V	AO2
20	**B**	1 into the page out of the page	AO2
21	**C**	6.1 V	AO2
22	**C**	13 mWb	AO2