OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL

PHYSICS

PH03

Unit 3 Fields and their consequences

Mark scheme

June 2025

Version: 1.0 Final

256XPH03/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 www.oxfordaqa.com

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.

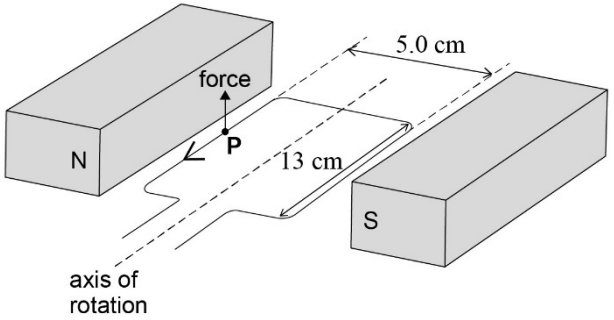
Step 2 Determine a mark

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	Current drawn as an arrow pointing along left-hand wire towards the front ✓	 If more than one arrow is drawn, all must be correct and at least one must show the direction at **P**.	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Any **two** from: ✓✓ • use of $F = BIl$ (with 13 cm) • use of couple $= Fs$ (with $s = 5$ cm) • use of $66F$ 0.048 (N m) ✓	Ignore PoT errors in first 2 marking points. If no other marks awarded condone 1 mark for use of $F = BIl$ and couple $= Fs$ with distances reversed. Condone the use of BIA for first two bullet points. Full marks can only be awarded for correct physics. If there is no moment calculation condone for mp3 a statement that there are **two** forces of **0.965 N** acting in opposite directions **separated** horizontally (by 0.050 m).	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	$\varepsilon = Blv$ or 75 ($\times 10^{-3}$) × 8.75 ($\times 10^{-2}$) × 2.3 seen ✓ 0.015(1) (V) ✓	Calculator value 0.01509375	2	1 × AO1 1 × AO2

Total			**6**

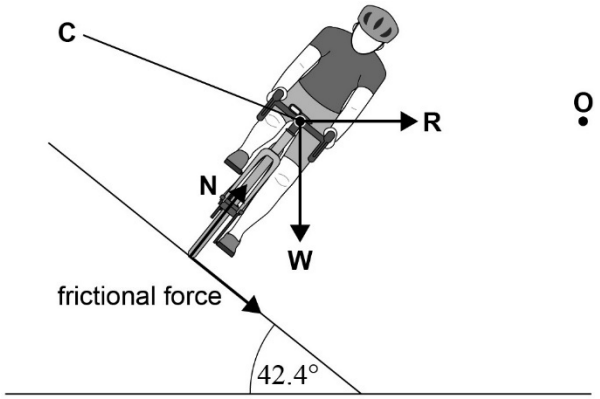
Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Substitution into $A = A_0 e^{-\lambda t}$ or valid rearrangement ✓ $t \left(= \frac{\ln\left(\frac{51}{121}\right)}{-3.08 \times 10^{-3}} \right) = 281$ (s) ✓	Allow use of $A = A_0\ 0.5^{-\frac{t}{t_{0.5}}}$ **and** $t_{0.5} = \frac{\ln 2}{\lambda}$ for 1st mark. Allow 2SF 280.	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Any **two** from: ✓✓ • use of $N = \frac{A}{\lambda}$ • use of $n = \frac{N}{N_A}$ for their N • mass = n × molar mass for their n mass = 1.4×10^{-12} (kg) ✓	Expect $\frac{51 \times 10^9}{3.08 \times 10^{-3}} = 1.6558 \times 10^{13}$ Expect $\frac{1.6558 \times 10^{12}}{6.02 \times 10^{23}} = 2.751 \times 10^{-11}$ Allow any answer that rounds to 1.4×10^{-12}	3	2 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	The uncertainty in the activity is very much less than the activity (for the sample) so an (accurate) prediction can be made. ✓ Cannot predict when a nucleus will decay / whether the nucleus will decay in $1\ \text{ms}$ ✓	For mp1 there must be the idea that a prediction can be made and any reference to randomness must include the idea that the variation is small. Condone for mp1 the activity / number of decays in one second for the large sample can be predicted. Condone atom for nucleus. Allow cannot predict which nucleus will decay for mp2.	2	AO2

Total			**7**

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Maximum frictional force $= \frac{mv^2}{r} = \frac{79.5 \times 14.2^2}{22.5} =$ 712(.4613333) N ✓	At least 3 sf required	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Any **two** from: ✓ • normal acting at right angles to the surface where the tyre meets the road • weight acting downwards from centre of mass • resultant (centripetal) force acting horizontally to the right, touching rider or bike All **three** ✓	 Max 1 if lines are not straight.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Finds horizontal component of N (expect $N \sin 42.4°$ or 701 N) ✓ Resolves towards **O** and attempts to set up equation $N \sin 42.4° + F_2 = \frac{mv^2}{r}$ ✓ Shows that $F_2 = 11.2$ (N) **and** $11.2 < 710$ ✓	Allow use of $F_2 \cos 42.4°$ in mp2. Allow ecf for wrong trig function in mp2. Allow F_1 or 710 or 712 or ecf from 3.1 for $\frac{mv^2}{r}$ Use of 710 leads to 8.7 N Use of 712 leads to 10.7 N Allow F_2 quoted to 1 SF. Allow algebraic approaches.	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Idea that **component** of normal contact force contributes to the centripetal force ✓ Idea that on the flat, friction = centripetal force ✓ Idea that on the bank (horizontal component) friction + (horizontal) component of reaction force = centripetal force ✓ Idea that the greater speed requires a larger centripetal force than **maximum friction** which the bank provides ✓	Condone 'provides' for 'contributes to' Do **not** allow centripetal force cancels or balances (component of) friction or normal contact force in mp1 or mp2. Ignore any suggestion that the weight contributes to the centripetal force in mp1 and mp3. Do **not** allow the idea that a greater force causes a greater speed in mp4. Do **not** allow the idea that the friction can be increased from its value in Fig 3 (max) in mp4. Do **not** allow any suggestion that the weight contributes to the centripetal force in mp4.	4	AO2

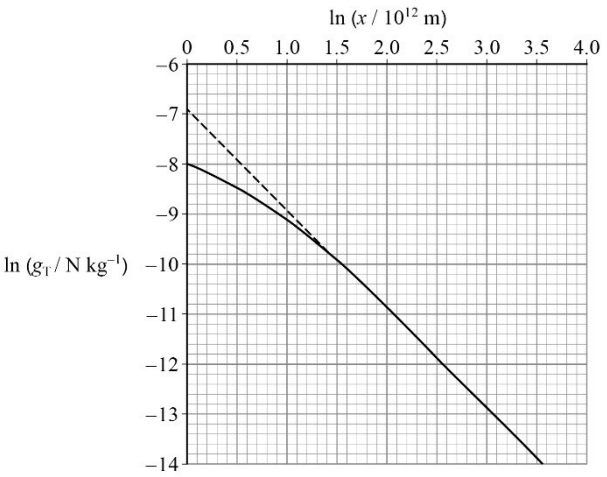
Total			**10**

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	The work done per unit mass ✓ in moving a (small test mass) from infinity to the point ✓	Ignore references to $V = -\frac{GM}{r}$ in symbols or words.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Any **one** from: ✓ • halve the potential or mass • use of $M = -\frac{Vr}{G}$ Mass of star **A** $= 8.0 \times 10^{30}$ (kg) ✓	Ignore PoT in MP1. $(7.994752624 \times 10^{30}$ or $7.99015296 \times 10^{30})$ Do **not** allow 1 SF.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Change in potential / change in distance based on values from their line ✓$_1$ Tangent drawn at their distance **AND** used for gradient with $\Delta V \geq 0.4\ \text{GJ kg}^{-1}$ ✓$_2$ $x = 0.70 \times 10^{12}$ to 1.70×10^{12} (m) ✓$_3$ **AND** $g_T = 1.63 \times 10^{-4}$ to 1.84×10^{-4} (N kg^{-1})	Condone misreads and data taken from curve for ✓$_1$ Condone misreads and missing or incorrect minus signs for gradient value in ✓$_2$ Allow $g_T = 1.6 \times 10^{-4}$ but not 1.60×10^{-4} **Alternative method for ✓$_1$ and ✓$_2$** value of x indicated on graph **and** $r = \sqrt{(1.5(\times 10^{12}))^2 + x^2}$ ✓$_1$ Use of $2\frac{GM}{r^2}\cos\theta$ (where $\cos\theta = \frac{x}{r}$) for their r, x and their M from 4.2 ✓$_2$ If $x = 1.5 \times 10^{12}$ is used then this simplifies to $g_T = \frac{GM}{\sqrt{2}x^2}$ or $\sqrt{2}\frac{GM}{r^2}$. Allow ecf for ✓$_3$ for their M in this method.	3	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Gravitational field strength is 0 at **O** ✓ Increases in magnitude (to a maximum as x increases), then decreases in magnitude (as x increases further) ✓	 Ignores comments about g_T for $x > 6 \times 10^{12}$ m	2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	**Annotate** graph with either straight line drawn as tangent to line at $\ln x = 3.5$ **OR** read-off where line stops being straight as $\ln x$ decreases in range 1.4 to 1.8✓ statement that line has to be straight **or** use of logged equation aligned with $y = mx + c$ **or** idea that gradient $= -2$ **or** use of e^x with their read off ✓ x_{min} rounds to between 4.5×10^{12} and 5.5×10^{12} (m) ✓	 Do **not** allow statement that $\ln x$ is (directly) proportional to $\ln g_T$ for MP2.	3	AO3

Total			12

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Use of $V = Ed$ ✓ 2.7×10^5 (V) ✓ 2 significant figures ✓	2.66×10^5	3	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Use of $F = QE$ ✓ Use of $F = ma$ ✓ 1.27×10^{15} (m s^{-2}) ✓	$a = \frac{QE}{m}$ scores mp1 and mp2.	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	The electric field is 0 / $\Delta V = 0$ / V is constant inside the cylinder ✓ So no work is done / there is no force / use of $a = \frac{QE}{m}$ or $a = \frac{QV}{dm}$ ✓ Vacuum so no collisions with gas particles (to slow protons down / change their direction) ✓	Ignore comments about gravity. mp2 depends on mp1. Do not allow no air resistance / drag.	3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Idea that protons travel faster in subsequent tubes ✓ Reference to $s = vt$ to give longer distance for same time ✓	Proton is accelerated is not enough for mp1.	2	AO2

Total			**11**

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	$(1 - e^{-1} =) 0.63$ ✓	Allow 63% 0.6321205588	1	AO1

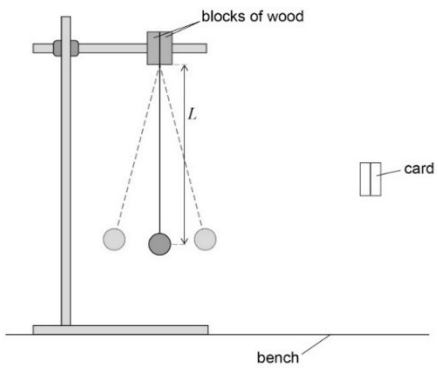
Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Reading of 5.5 ± 0.1 (mA) for y-intercept **and** $R = \frac{6}{\text{their current}}$ seen ✓ 1071 to 1111 (Ω) to at least 2 sf ✓		2	1 × AO2 1 × AO3

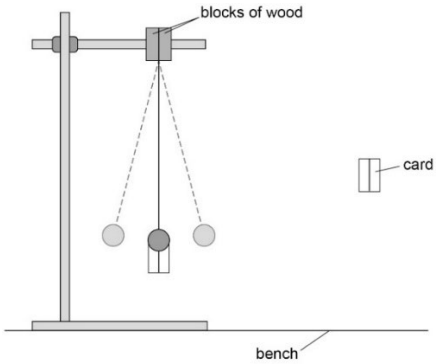
Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Use of $I = I_0 e^{-\frac{t}{RC}}$ with data from graph ✓ Time constant = 7.5–8.7 (s) ✓ Capacitance = $\left(\frac{\text{their time constant}}{\text{their answer to } \mathbf{06.2}}\right)$ ✓	Condone 3 SF readings from graph. Allow use of $V = V_0(1 - e^{-\frac{t}{RC}})$ with $V = \varepsilon - IR$ or $V = IR$ with $I = 3.1 \times 10^{-3}$ Allow use of $V = Ve^{-\frac{t}{RC}}$ with $V = IR$ for $t \geq 7\ s$ Allow use of $t_{0.5} = 5.8 \pm 0.2$ **and** time constant = $\frac{t_{0.5}}{\ln 2}$ Do **not** allow 1SF but only penalise once. Expect around 7.5×10^{-3}	3	AO3

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>06.4</td><td>
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas covered in some detail.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.
However, for 6 marks an explanation for the negative current after 7 s must be present.</td></tr>
<tr><td>5</td><td>All three areas covered, at least two in detail.
Whilst there will be gaps, there should only be an occasional error.</td></tr>
<tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.</td></tr>
<tr><td>2</td><td>Only one area discussed or makes a partial attempt at two areas.</td></tr>
<tr><td>1</td><td>None of the three areas covered without significant error.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table>
</td><td>Changes from $t = 0$ to $t = 7$ s
• capacitor charges
• voltmeter reading / voltage (across the capacitor) increases
• increasing charge / charge is stored on capacitor
• Use of $Q = CV$
Treat references to an exponential change in V as neutral. BP3 implies BP1.

Relationship between meter readings
• voltage across capacitor increases so voltage across resistor decreases, so current falls
• making it more difficult for charge to be added to capacitor/move round circuit, so current falls
• current = voltage across resistor/ resistance of resistor
• emf = voltage across capacitor (voltmeter reading) + voltage across resistor
ammeter reading decreases since $I = \frac{\varepsilon - V}{R}$ (with any subject) and V increases, fully addresses this area.

Changes after $t = 7$ s
• current flows in opposite/different direction when discharging (hence negative)
• capacitor discharges
• voltage / voltmeter reading and current decreases exponentially
• voltage across capacitor falls so voltage across resistor falls, so current falls
(must mention voltage across the resistor)
• charge falls on capacitor so less force on pushing charges round circuit so current falls</td><td>6</td><td>2 × AO2
4 × AO3</td></tr>
<tr><td>Total</td><td></td><td></td><td>12</td><td></td></tr>
</table>

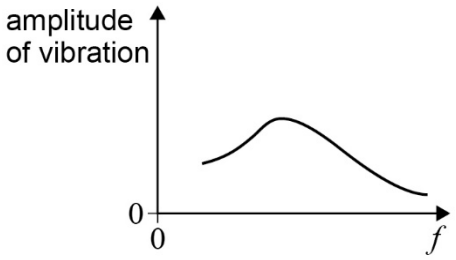
Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	**Double-headed arrow** drawn from bottom of blocks of wood to level with the centre of the pendulum bob ✓		1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Vertical line / centre of card aligned with string in vertical position. Part of card should be behind the bob ✓ The bob is moving fastest here (so the uncertainty in judging the time when it passes the mark is smallest) / transit time is least ✓	Condone a card fully below the bob.  Condone maximum kinetic energy for fastest. Do **not** award the second mark if the card is drawn so that no part is in line with the vertical string. Ignore references to reaction time	2	1 × AO3 1 × AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Any **two** from: ✓✓ • measure nT and divide by n for $n \geq 10$ • repeat and average (T or nT) • repeat and remove anomalies • ensure pendulum is viewed perpendicular to oscillations • ensure that the pendulum is only allowed to swing through a small angle (6°) / small amount / small-amplitude oscillations	Condone: • pendulum only allows to swing through angle of $\leq 15°$ • countdown method for timing • use a longer pendulum • use a more massive ball/bob to reduce the impact of air resistance • use a smaller bob (with same mass) to reduce the impact of air resistance • record a video **and** view in slow motion/pause playback/use of software to analyse motion • use of position sensor **and** datalogger • use of light gate which ball passes through **and** datalogger/timer Reject use light gates / electronic timing without clarification Apply the list principal.	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Recorded half oscillations instead of full oscillations ✓ $g\left(=\frac{39.1}{4}\right) = 9.78\ (\text{m s}^{-2})$ ✓	 If 9.8 quoted there must be evidence of dividing by 4.	2	AO3

Total			**7**

Question	Key	Answer	AO
08	**C**	$0.37\ \text{m s}^{-1}$	AO1
09	**D**		AO1
10	**A**	$\frac{R}{4}$	AO1
11	**D**	$9.0\ \text{nC}$	AO2
12	**A**	A s V^{-1}	AO1
13	**C**	$0.08 \quad 3.6$	AO2
14	**D**	8.37×10^{19}	AO2
15	**B**	ln(number of decayed nuclei) against ln(time)	AO1
16	**B**	The kinetic energy of the particle is constant.	AO1

17	**C**	69°	AO2
18	**C**	2A 0.5f	AO2
19	**A**	**P** and **R** arrive together, followed by **Q**.	AO1
20	**D**	8 A	AO2
21	**C**	95%	AO2
22	**C**	2.8 cm	AO2

Total marks = 15