OXFORD AQA
INTERNATIONAL QUALIFICATIONS

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

Mark scheme

January 2024

Version: 1.0 Final

241XPH03/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	Uses $T\cos\theta = mg$ to get 320.2 (N) to at least 4sf ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Uses $T_A \sin\theta_A = mr\omega^2$ ✓1 Uses $r = D + 6.0 \sin\theta_A$ ✓2 Uses $\omega = \frac{2\pi}{T}$ ✓3 5.8 (m) ✓4	Condone use of $T_A \sin\theta_A = m\frac{v^2}{r}$ with substitutions for MP1 $D = \frac{T_A \sin\theta_A}{m\omega^2} - 6.0 \sin\theta_A$ ✓1 ✓2 Expect to see $0.924\ \text{rad s}^{-1}$	4	AO1 2×AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Resolves horizontally and vertically and attempts to combine the equations ✓ Combines correctly and cancels m to give $\tan\theta_A = (D + l\sin\theta_A)\omega^2$ plus conclusion that θ is not affected by m (as m does not appear in the equation) ✓	Expect to see: $mg = T_A\cos\theta_A$ AND $\frac{mv^2}{r} = T_A\sin\theta_A$ OR $mr\omega^2 = T_A\sin\theta_A$ ✓ $\tan\theta_A = \frac{mv^2}{r} \times \frac{1}{mg}$ OR $\tan\theta_A = \frac{mr\omega^2}{mg}$ with m cancelled and conclusion ✓ Max 1 if weight used rather than mass	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	$\theta_B < \theta_A$ and $T_B < T_A$ ✓ $\text{Tan}\,\theta = \frac{r\omega^2}{g}$ AND idea that as r increases θ increases ✓ $T = \frac{mg}{\cos\theta}$ AND idea that T and cosθ are inversely proportional OR when θ is bigger cosθ will be smaller OWTTE ✓		3	AO1 2×AO2
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Downward arrow labelled mg / weight / W AND upward arrow labelled tension or $k\Delta L$ or T ✓	Condone kx for T Arrows must be drawn on the diagram coming from jumper and must be straight.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Uses resultant upward force $= k\Delta l - mg$ OR $F = ma$ with their resultant force ✓ 43 (m s^{-2}) ✓	Expect to see 2490 N Award 1 mark for use of $k\Delta l = ma$ for resultant force and final answer of 53(m s^{-2}) Alternative if k interpreted as a field strength: Resultant force = $km - mg$ OR $F = ma$ with their resultant force ✓ (= (161 x 58) – (58 x 9.81)) 151 (ms^{-2})✓ Award 1 mark for use of $km = ma$ for resultant force and final answer of 161 (m s^{-2})	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Uses $mg = k\Delta l$ to find equilibrium extension ✓ subtracts from 19 to give $15.5\ (\text{m})$ ✓ (ecf)	Expect to see $3.53\ (\text{m})$ Alternative for MP1: Determines T and uses $$Their\ a_{\max}\ (\text{from } 2.2) = \left(\frac{2\pi}{their\ T}\right)^2 A$$ Allow 2sf $15\ (\text{m})$ Note using 53 from 2.2 gives $\omega = 1.67\ \text{rad s}^{-1}$ ✓ $\text{A} = 19\text{m}$ ✓	2	AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Determines their value of T ✓ Halves their period to get their final answer ✓ 1.9 (s) ✓	E.g. for MP1 use of $T = 2\pi\sqrt{\frac{m}{k}}$ OR use of $\omega = \sqrt{\frac{their\ a_{max}(from\ 2.2)}{their\ A\ (from\ 2.3)}}$ AND $T = \frac{2\pi}{\omega}$ Expect to see $T = 3.77\text{s}$	3	AO1 2×AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	Idea that in SHM force is proportional to displacement (from equilibrium position) ✓1 In this motion the force is constant ($= W = mg$) when the rope is slack ✓2 OR Idea that in SHM acceleration is proportional to displacement (from equilibrium position) ✓1 In this motion the acceleration is constant (g) when the rope is slack ✓2	Allow $F = -kx$ with terms defined for MP1	2	AO1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.6	Idea that not all of the stored elastic potential energy is recovered in plastic deformation ✓	Allow some EPE is converted / lost to heat Damping on its own is not enough for mark	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.7	Two from: ✓✓ • Data extraction from graph: period of oscillation is 3 s • use of $E = \frac{1}{2} m\omega^2 A^2$ for initial A OR final A • their difference between two energies ÷ 21 24 (W) ✓	 Expect to see 20.8 J OR 520 J Expect to see 500 ÷ 21 23.81 (W)	3	AO1 2×AO3
Total			**14**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Vertically downwards ✓	Condone perpendicular to the dees / path for vertical	1	AO3

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>03.2</td>
<td>The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2- mark (L1), 3- or 4- mark (L2) and 5- or 6- mark (L3) answer.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas covered satisfactorily.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>Two areas covered satisfactorily and one partially.</td></tr>
<tr><td>4</td><td>Two areas covered satisfactorily, or one covered satisfactorily 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 covered satisfactorily 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 covered satisfactorily, 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>
</table>
</td>
<td>Linear acceleration between the dees
• There is an electric field because there is a potential difference between the dees.
• Proton experiences a force due to the electric field.
• Reference to $F = ma$
• The pd reverses while the proton is in one dee so the proton accelerates towards the next dee.
Circular path in the dee
• There is a magnetic field at right angles to the velocity of the proton.
• Reference to force on a moving charge in a magnetic field and $F = Bqv$
• Moves in a circular path since force is always at right angles to velocity or refers to Bqv as the centripetal force.
Increase in radius in the path
• Increasing v due to electric field leads to increasing r in magnetic field.
• Acceleration greater in next dee as velocity is greater so radius is greater (may refer to $Bqv = m\frac{v^2}{r}$ and $EQ = ma$)</td>
<td>6</td>
<td>2×AO1
2×AO2
2×AO3</td>
</tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Recognises that there is no change in angular velocity as cyclotron frequency is constant ✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Uses $E = \frac{1}{2}mv^2$ ✓ 4.8×10^7 $(\mathrm{m\ s^{-1}})$ ✓	“Uses” means by substitution or rearrangement Condone power of 10 error in substitution into equation in MP1	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	One from: ✓ • $\omega = v/r$ • $f = \frac{v}{2\pi r}$ • $T = \frac{2\pi r}{v}$ Correct working leading to 146 ✓	Look for $\omega = 2.66 \times 10^8\ \mathrm{rad\ s^{-1}}$ $f = 42.4\ \mathrm{MHz}$ $T = 2.36 \times 10^{-8}\ \mathrm{s}$ Allow 147 Do not allow methods that assume constant path circumference for all revolutions.	2	2×AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.6	Divides 1.92×10^{-12} by 146 or 147 or 150 OR Uses their $W = qV$ ✓ finds peak to peak voltage ✓ and then divides by 2 to get $2.0(4) \times 10^{4}$ (V) ✓	Expect to see 1.315×10^{-14} (J) or 1.28×10^{-14} (J) Expect to see 8.22×10^{4} (V) or 8.0×10^{4} (V) Expect to see 4.1×10^{4} (V) Allow answers that round to 2.1×10^{4} (V)	3	AO1 2×AO2
Total			**15**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Uses $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ OR uses $A = A_0 e^{-\lambda t}$ ✓ Uses both equations to get $5.2(1) \times 10^{14}$ (Bq) to at least 2 sf ✓	Expect to see 0.337 yr^{-1} or 1.065×10^{-8} s^{-1} Condone POT error in MP1 Do not condone the use of mixture of years and seconds in substitutions for MP1 Calculator value is $5.206947078 \times 10^{14}$ Accept getting activities the wrong way round for MP2 only	2	AO2 AO3

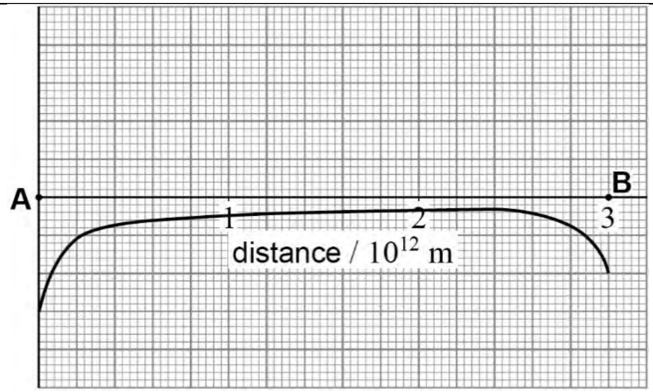
Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Uses $A = \lambda N$ ✓ Divides by 6.02×10^{23} OR multiplies by 134 ✓ 11 (g) ecf ✓	Expect to see approx. 4.9×10^{22} Expect to see approximately 0.08 moles Show that value gives 10.485 g	3	2×AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Evidence of a correct conversion from MeV to J ✓ 69 (W) ✓	Accept 66 (W) for candidates who use 5×10^{14}	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Idea that collisions between the β^- particles and ions in the fuel increase the vibrational / kinetic energy of the ions ✓ The idea that (electron) (anti) neutrinos carry away some of the decay energy and this is lost (as neutrinos have extremely weak interactions with other matter) ✓	Condone thermal energy for kinetic energy Accept that beta may escape from the rod without losing all of its kinetic energy for MP2	2	AO1 AO2
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	MAX 3 ✓✓✓ • The resultant gravitational field is the (vector) sum of the fields from **A** and **B** • Idea that for points near and **A** and near **B** the gravitational field strength is greater for **A** than for **B** as the mass of **A** is greater. • The sign changes because the direction of the force (per unit mass) changes direction • **X** is near to **B** as **B** has the smaller mass – or reverse argument	If no other mark awarded give 1 max for idea that at X the field strength from **A** is equal and opposite to field strength from **B**.	3	AO2 2×AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Uses $g = \frac{GM}{r^2}$ or $r_B = 3 \times 10^{12} - 1.76 \times 10^{12}$ ✓ Equates g for **A** and **B** ✓ 2.0×10^{30} (kg) ✓	Expect to see $r_B = 1.24 \times 10^{12}$ m $M_B = \frac{r_B^2 M_A}{r_A^2}$ with values substituted gets MP1 and MP2 Calculator value = $1.98553719 \times 10^{30}$	3	AO1 2×AO2

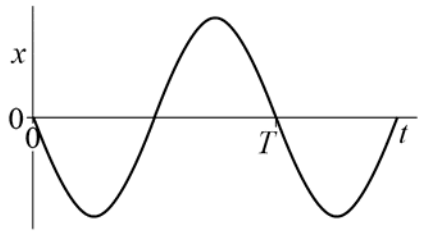
Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	All values negative and general shape is correct ✓ Magnitude of the value at **A** greater than magnitude of the value at **B** OR non-zero maximum nearer to **B** than **A** ✓	 Condone maximum potential at point **X**	2	2×AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Change in flux linkage (as the current goes from a maximum to zero) ✓		1	AO2
06.2	Feature stated with explanation consistent with an increase in $\frac{\Delta\Phi}{\Delta t}$ ✓ Different feature stated with explanation consistent with an increase in $\frac{\Delta\Phi}{\Delta t}$ ✓	Eg: Feature – Switch Reasoning - Idea that value for Δt is small (so $\frac{\Delta\Phi}{\Delta t}$ is large). Feature – Increase battery V / reduce resistance R Reasoning - Idea that value for $\Delta\Phi$ is large (so $\frac{\Delta\Phi}{\Delta t}$ is large).	2	AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Uses $\Phi_s = BAN_s$ or divides by N_s ✓ Does both and rearranges to give $B = \mu N_p I$ or $B = \mu N_p \frac{E}{R}$ ✓	$\Phi_s = BAN_s = \mu N_p N_s A \frac{E}{R}$ Treat calculations as neutral	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Uses $E = \frac{\Delta\Phi}{\Delta t}$ and with E and ε correct✓ 4.5×10^{-7} (s) ✓	Correct answer with some correct working gets full marks. Calculator value is 4.536×10^{-7}	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.5	Current larger (for smaller resistance and constant pd) so greater flux / flux density ✓ Larger emf as greater change in flux (linkage in same time) ✓		2	2×AO4
Total			**9**	

Question	Key	Answer	AO
07	**C**	$\text{kg}^{-1}\ \text{m}^{3}\ \text{s}^{-2}$	AO2
08	**B**	**P** | **Q**	AO1
09	**C**		AO3
10	**A**	0.67	AO2
11	**B**	the gradient at **P**	AO3
12	**A**	**P** and **R**	AO3
13	**D**	$\sqrt{3}\pi Af$	AO2
14	**C**	10^{10}	AO2
15	**B**	$\frac{\sqrt{3}}{2}BIL$ | into the page	AO4
16	**B**	decrease | increase	AO2

<table>
<tr><td>17</td><td>B</td><td>26 s</td><td>AO3</td></tr>
<tr><td>18</td><td>D</td><td>in any metal in a changing magnetic field.</td><td>AO1</td></tr>
<tr><td>19</td><td>C</td><td>10 V / division</td><td>AO2</td></tr>
<tr><td>20</td><td>A</td><td>$\frac{N_P^{\,2}}{N_S^{\,2}} I_P^{\,2} R$</td><td>AO3</td></tr>
<tr><td>21</td><td>D</td><td><table><tr><td>lines of equipotential</td><td>the lines are close together</td></tr></table></td><td>AO3</td></tr>
</table>