OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL

PHYSICS

PH03

Unit 3 Fields and their consequences

Mark scheme

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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	Arrow(s) upwards with suitable label e.g. reaction or N or R **AND** Single arrow downwards with suitable label e.g. weight or W or mg ✓ Starting point of downward arrow near to centre (of mass) of person AND Starting point of two upwards forces at feet of person AND Length of downward arrow about double that of upward arrows ✓	Condone alternative labels e.g. 'normal', 'contact force', 'gravity', 'gravitational (force)'. Reject 'F' **MAX 1** if there are any horizontal forces e.g. friction. Reject answer that includes extra vertical forces. The judgement about the length is by eye.	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Arrow, the line of action of which is directed through the person towards centre of station ✓	Ignore labels Reject arrows that are too short or wobbly to prevent judgement of direction.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Idea that people (on Earth) experience weight due to reaction force (from "ground") ✓ Links reaction force to centripetal force/acceleration.	Allow MP1 for answers that refer to simulation of gravity and refer to the reaction (from spacestation wall). Allow 'normal force' for 'reaction force' Allow 'force towards the centre' for centripetal force.	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Equates g to an equation for centripetal acceleration ✓ Evidence of v or ω, OR use of their v in $p = mv$ or ω in $p = mr\omega$ ✓ 65 (kg) ✓	Can be seen by substitution or symbols. Look for $v = 38\ \text{m s}^{-1}$ Allow use of 148 to 150 m for 'r' Expect answer that rounds to 65 (kg) unless 148 used to give an answer rounding to 66 (kg)	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	Idea that ball will move in a straight line to the right/ maintain a constant velocity/ maintain its momentum ✓ idea that there are no forces acting on ball ✓ Explanation in terms of Newton 1 or 2 ✓	Reward evidence seen on diagram. Allow MP2 for idea that there is no centripetal force if supported by MP1 or MP3.	3	AO2
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Idea that when y is a maximum all of the energy is (gravitational) potential energy ✓ Idea max value of y is constant (so same total energy) ✓		2	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Reads off maximum y and relates it to GPE = mgy $_1$✓ Relates max GPE to max KE $_2$✓ 1.08 to 1.1 (m s^{-1}) $_3$✓	0.061 m. Accept 0.060 to 0.062. Reject 0.06 seen in working. For MP1 and MP2, allow alternative use of amplitude and shm e.g.: Reads off max y and relates it to max angle = cos^{-1} ((1.8 – y) ÷1.8) (= 15.0^o) $_1$✓ Finds amplitude (0.47 m) and ω and uses $v = wA$ $_2$✓ If not other mark awarded, allow **1 MAX** for use of $v=\omega A$ with a calculated ω and A=0.061	3	AO3 × 1 AO2 × 2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Determines period of shorter swing using **Figure 5** ✓ Use of *their* $T = 2\pi\sqrt{\frac{l}{g}}$ ✓ l = 0.72 to 0.56 OR idea that the length of shorter pendulum = 1.8 – h ✓ 1.08 to 1.24 m ✓	Accept 1.5s to 1.7s Use of means by correct substitution or rearrangement.	4	AO3 × 2 AO2 × 2
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Idea that zero of E_p is at infinity ✓ idea that E_p increases as d increases/moving towards infinity OR Work is done as d increases/for object to reach infinity✓	For MP2 allow idea that the field is attractive only if MP1 is given Allow reverse argument in MP2. Allow references to potential for E_p	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	At maximum, (force of) attraction from Moon = (force of) attraction from Earth OR (resultant) gravitational field strength is zero ✓ E_p increases going away from Moon when attracted to Moon OR E_p decreases towards Earth when attracted to Earth✓	If no other mark awarded allow **MAX 1** for idea that the gravitational field strength of the Earth is greater than the gravitational field strength of the Moon when $d > 4 \times 10^7$ (m)	2	AO1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Evidence of tangent drawn on **Figure 7** at $d = 1.0 \times 10^7$ m ✓ Calculation of gradient of a straight line✓ Their gradient divided by 37 kg to give 0.039. ✓	Only penalise POT in final answer Expect to see gradient = 1.4 and field strength = 0.039 (N kg^{-1}) Allow 0.035 to 0.044 with working. If no other mark awarded allow **MAX 1** for evidence of their Ep divided by 37 kg.	3	AO3 × 2 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Determines maximum GPE from **Figure 7** ✓ Equates **change** in GPE (from Moon to max) to KE (at Moon) OR Uses KE equation with any value of Ep to determine their v ✓ Answer that rounds to 2.2×10^3 m s^{-1} ✓	Accept (–) 4.7×10^7 (J) to 4.9×10^7 (J) seen Expect 9.1 to 9.3×10^7 (J) for change in GPE Do not allow approach based on escape velocity of the Moon.	3	AO3 × 1 AO2 × 2
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Evidence of attempt to equate weight and force due to electric field ✓ $mg = EQ = Q\left(-\frac{V}{d}\right)$ ✓	In MP1 it is sufficient to see mg replacing F in an equation where F is the force due to the electric field. In MP2 some indication of negative sign eg force due to electric field is in opposite direction to E or idea that $F_E + F_G = 0$ accept evidence from labels on diagram but 'oil drop is negative' is insufficient.	2	AO1 × 1 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Attempts to use $\frac{V}{d}$ to obtain field strength due to plates ✓ Attempts to use $E = \frac{Q_1}{4\pi\varepsilon_0 r^2}$ for oil drop ✓ Finds difference between (magnitudes of) their MP2 their MP1 ✓ $8.7(5) \times 10^3$ N C^{-1} ✓ Direction consistent with difference in their two field strengths. ✓	Condone POT errors in MP1 and MP2. Only condone use of d= 0.75 (mm) for incorrect field strength due to plates. Expect to see 1.1×10^4 N C^{-1} Expect to see 1.9×10^3 N C^{-1} Accept 8.7×10^3 N C^{-1} Expect (E due to plates > E due to oil drop so direction is) downwards.	5	AO2 × 4 AO3 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Two from ✓✓ • upper plate less positive / lower plate more positive / decrease OR turn off pd across plates / reverse (polarity of) plates/ upper plate negative • increases separation of plates • (negative) charge on oil drop decreased / oil drop has lost (an) electron(s)/ oil drop is positive • idea that oil drop combines with an uncharged or positive drop or a drop with a lower specific charge		2	AO1
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Idea that the shaded area is the charge **moved** (in 6 s) ✓ Charge remaining = initial charge – charge moved ✓	Condone 'total' for 'initial' Do not accept 'total area' for initial charge.	2	AO3 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Reads off current at $t = 0$ OR *Their answer for emf* = IR for their max I ✓ 6.3 V ✓	Allow 28 to 29 (μA) Accept POT error in MP1 Do not allow answer based on area under the curve. Accept 6.2 to 6.4 V	2	AO3 × 1 AO2 × 1

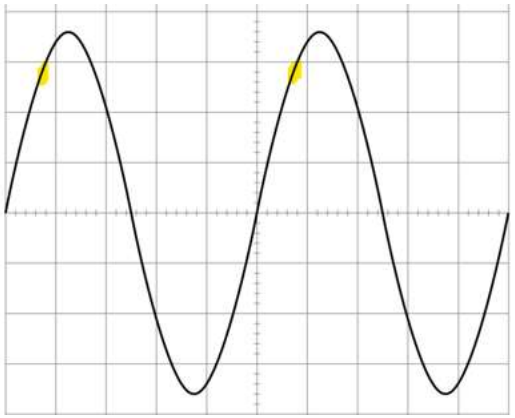
Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Attempts to determine RC from the graph OR evidence of use of discharge equation OR use of 'half-life' ✓ 1.2×10^{-5} (F) ✓	Expect to see an RC that rounds to 3 s ✓ Allow 1.0 to 1.4 × 10^{-5} consistent with their read-offs. If no other mark awarded, allow **MAX 1** for evidence of estimation of area under graph leading to an answer of 1.0 to 1.4 × 10^{-5} (F)	2	AO3 × 1 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Complete circuit with either ammeter or resistor' in series with capacitor connected to moving part of switch✓ Complete circuit with both ammeter and resistor in series with capacitor on moving part of switch ✓		2	AO4

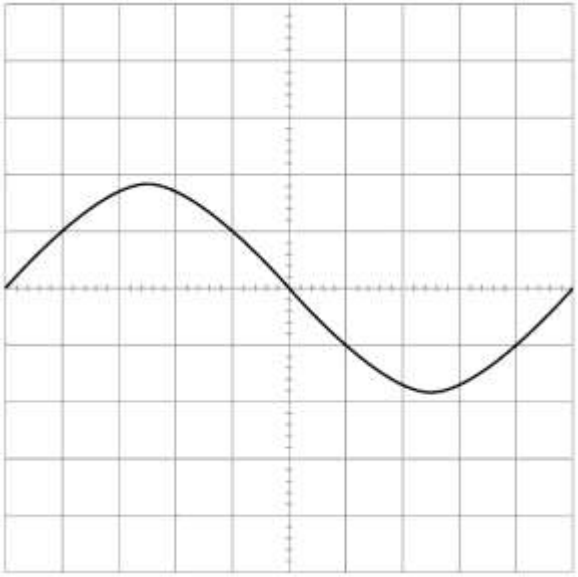
Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	Line with decreasing negative gradient ✓ that follows the dotted line on the graph ✓	MP2 is contingent on MP1 Do not condone line that ends abruptly at the time axis. In MP2 do not condone line that is consistently above or consistently below the dashed line.	2	AO2
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	(Use of flux linkage = $BAN\cos\theta$) 121 (turns) ✓	Accept 2sf 120 turns. Must be whole number.	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Idea that as angle changes flux linkage changes ✓ States and applies Faraday's law eg an emf is induced when the flux (linkage) changes ✓	Accept perpendicular area or effective area for angle. Allow alternative MP2 eg 'emf is proportional to rate of change of flux linkage' Do not award MP2 for an equation without support. Allow equation for Faraday's law provided N is included or Φ is defined as the 'flux linkage'.	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	**X** positioned on the trace 0.7 of a square from start or equivalent ✓ Evidence of calculation eg Position on time axis is 5 squares × $51 \div 360$ OR position on V axis = $V_{max} \times \sin(51^{o})$✓	Allow **X** on the line above the middle of the square by eye 	2	AO2 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Determines period or number of squares for one period ✓ Determines peak emf or number of squares for peak ✓ Time base = 4 ($\mathrm{ms\ cm^{-1}}$) y-gain = 0.5 ($\mathrm{V\ cm^{-1}}$)	Expect to see 20 (ms) or 5 squares Expect to see 1.8 (V) or 3.6 squares Only accept 1 sf answers	4	AO3 × 2 AO4 × 2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.5	Sinusoidal with any initial phase AND half the height of **Figure 14** ✓ double the period of **Figure 14** ✓	 For multiple curves judge the first cycle for how sinusoidal it is. Ignore vertical shift in MP2.	2	AO3
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Three from✓✓✓ • Attempts to determine decay constant • Use of A =their λN • Use of $n = \frac{N}{N_A}$ OR mass = n × molar mass • Calculates their difference between amount/mass for 39kBq and 32kBq 5.5×10^{-11} kg ✓	5.1×10^{-11} s^{-1} Allow alternatives for MP3 e.g. use of 241 x mass of nucleon Allow use of $\Delta A = \lambda \Delta N$ to give evidence for MP2 and MP4	4	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Half-life of Np is (much) greater than half-life of Am OR Decay constant/probability of decay of Np is (much) smaller than Am AND therefore the activity (of the Np) is very low owtte✓	Accept idea that the kinetic energy of the alpha particles may be too low. Allow the idea that the Np is 'more stable' but reject idea that Np **is** stable. Allow idea that the Np half-life is very short so it does not extend the combined half-life/ the time for which the particles are emitted.	1	AO2
Total			**5**	

Question	Key	Answer	AO
08	**A**	maximum | zero	AO1
09	**C**	$2\pi\sqrt{\frac{M\Delta l}{(M+m)g}}$	AO2
10	**D**	$2.32F$	AO2
11	**D**	$\frac{4\pi^2}{GM}$	AO1
12	**B**	there is no force | there is a force	AO1
13	**D**	The forces on the horizontal sides of the coil are in opposite directions.	AO3
14	**C**	2.5 | 0.9	AO1
15	**C**	circular | straight	AO1

16	**C**	It decreases to a constant negative value.	AO2
17	**B**	Q | $< E$	AO2
18	**B**	0	AO2
19	**B**	3.6×10^{7} m	AO1
20	**C**	Their size depends on the resistivity of the material of the core.	AO1
21	**A**	E | 0	AO1
22	**A**	r is the separation of the centres of the spheres.	AO1

Total – 15 marks