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

Mark scheme

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226XPH03/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	Marking guidance	Mark	Comments
01.1	Multiply the number of (vertical) squares by the volts/div ✓ *And any two of:* Turn off the timebase ✓ Increase the y-gain/decrease the volts/div so the trace takes up more of the screen vertically owtte ✓ Read off the <u>peak-to-peak</u> voltage and halve it ✓	3	Condone 'adjust' for increase/decrease if meaning is clear

Question	Marking guidance	Mark	Comments
01.2	no. of squares found for multiple cycles (accept 9.6 to 10 squares for four cycles here) ✓ their reading of cycle squares multiplied by the timebase (can be implied) OR use of $\omega = 2\pi / T$ ✓ leading to ω = 12.7-13.1 (rad s^{-1}) ✓	3	MP1 requires multiple cycles Alternative for MP1, MP2: frequency found using multiple cycles ✓ use of $\omega = 2\pi f$ ✓ At least 3sf

Question	Marking guidance	Mark	Comments
01.3	50 ✓ ms/div(ision) ✓ idea of one cycle filling the screen ✓	3	Expect to see 0.49/10 or 0.049 (s) Accept: an integer multiple of 50 (ms) for mp1 IF idea of having multiple cycles and taking an average given for mp3 ✓✓ MP2 dependent on MP1 Accept ms/cm or ms or s for MP2, if unit matches number

Question	Marking guidance	Mark	Comments
01.4	Use of $\varepsilon_{max} = BAN\omega$ ✓ $B = 0.039$ (T) ✓ ecf on their value of ω from 1.2	2	Condone rms ε for MP1 0.038 (T) if 13 rad s^{-1} used

Question	Marking guidance	Mark	Comments
01.5	Use of $V_{rms} = \frac{V_0}{\sqrt{2}}$ ✓ Use of $P = \frac{V^2}{R}$ ✓ $P_{mean} = 1.0(4) \times 10^{-4}$ (W) ✓	3	Full credit for correct answer without working

Total		14

Question	Marking guidance	Mark	Comments
02.1	Starts with $\frac{GMm}{r^2} = \frac{mv^2}{r}$ ✓ Substitution of KE = $\frac{1}{2}mv^2$ leading to KE = $\frac{GMm}{2r}$ ✓ Adds GPE = $-\frac{GMm}{r}$ ✓	3	Mp1 must be a combination of gravitational force and centripetal force

Question	Marking guidance	Mark	Comments
02.2	Any two: Idea that satellite requires energy to move away from the Moon AND potential energy is zero at r = infinity ✓ It is a bound system because of Moon's gravitational attraction OR magnitude of KE is less than magnitude of negative GPE wtte ✓	2	MP1 explains why GPE is negative MP2 explains why overall energy is negative

Question	Marking guidance	Mark	Comments
02.3	some form of $v = \sqrt{\frac{GM}{r}}$ ✓ correct substitution seen including correct mass ✓ $= 1.58 \times 10^3$ (m s^{-1}) ✓	3	MP1 can be squared and can be algebraic or with incorrect mass substituted Substituted mass must be Moon's (7.3 x 10^{22} kg) in MP2

Question	Marking guidance	Mark	Comments
02.4	Thrust/force is opposite to motion so work is done reducing total/gravitational potential energy ✓ link to r-dependence of total energy equation ✓	2	Treat any references to kinetic energy as neutral

Question	Marking guidance	Mark	Comments
02.5	Use of *difference in total energy* $= -\frac{GMm}{2r_2} - -\frac{GMm}{2r_1}$ ✓ $= 6.7\times 10^7$ (J) ✓	2	Subtraction can have the energy terms in either order If GPE is used in MP1, relationship to total energy must be clear (calculator value 6.748579×10^7 J)

Total		**12**

Question	Marking guidance	Mark	Comments
03.1	The number of nuclei decaying per unit time ✓	1	Reject ‘atoms’ for nuclei Do not accept ‘per second’

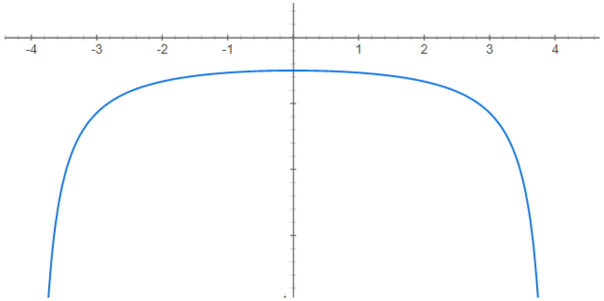
Question	Marking guidance	Mark	Comments
03.2	On average, 1 dice in 6 $(=0.17)$ is removed every minute OWTTE ✓	1	Accept the probability of decay per minute λ is the ratio of activity/removed-dice to number, in this case $1/6=0.17$ or $\lambda = \ln(6/5)$ derived from $N = N_0 e^{-\lambda t}$ (yields 0.18 min^{-1})

Question	Marking guidance	Mark	Comments
03.3	Use of $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ ✓ $= 4.2$ (min) ✓	2	*Alternative:* $\left(\frac{5}{6}\right)^T = \left(\frac{1}{2}\right)$ ✓ $T_{\frac{1}{2}} = 3.8$ (min) ✓ 3.5 (min) if $\lambda = 0.2$ is used Accept 1sf answer if working is seen Accept 5 min if clearly justified ecf from 03.2

Question	Marking guidance	Mark	Comments
03.4	Substitution into $N = N_0 e^{-\lambda t}$ ✓ Correct rearrangement using natural logs ✓ $t = 19$ (min) ✓	3	Allow only 1 mark for repeatedly dividing by six or two 16 min if $\lambda = 0.2$ is used

Question	Marking guidance	Mark	Comments
03.5	Only a small number of dice **or** dice rolls are random events ✓	1	Accept: dice rolls are discrete events whereas the decay of a sample is a continuous process ✓ Answer must be in terms of dice
Total		**8**	

Question	Marking guidance	Mark	Comments
04.1	Use of $E_{\text{res}} = 2E\cos\theta$ *AND* use of $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ ✓ distance to one charge found $(= 5.0\text{ mm})$ *OR* $\cos\theta$ OR θ calculated correctly ✓ $Q = -3.2 \times 10^{-12}$ (C) ✓	3	($\cos\theta = 0.6$; $\theta = 53^{\circ}$) Condone missing minus sign Allow answers between –3.2 and -3.3 × 10^{-12} (C)

Question	Marking guidance	Mark	Comments
04.2	Any smooth curve that is always negative✓ MP1 AND with a non-zero maximum at y-axis AND asymptotic at 4, -4✓	2	Condone touching x-axis for MP1 Allow 1 for the correct curve reflected in x-axis Expect: 

Question	Marking guidance	Mark	Comments
04.3	Direction is always towards O owtte ✓ Idea that both Q charges will repel m, and the nearer Q will repel more ✓	2	

Question	Marking guidance	Mark	Comments
04.4	Electric potential energy is transferred to kinetic energy (as it approaches the centre) OR EPE decreases and KE increases✓ Decrease in EPE is equal to the increase in KE ✓	2	Max 1 for answers including idea that EPE=0 at the centre Accept for MP2 no net energy difference Condone missing 'electric' for MP2

Question	Marking guidance	Mark	Comments
04.5	No, it is not, because force/field strength/acceleration is not proportional to distance (from O) ✓	1	(instead it goes approximately like $-1/r^2$) Accept correct reference to Figure 8

Total		**10**

Question	Marking guidance	Mark	Comments
05.1	37 milli coulombs (stored) per volt ✓	1	Allow 37mC and 1V instead of full words

Question	Marking guidance	Mark	Comments
05.2	The capacitance doubles **and** reference to $C = \frac{\epsilon A}{d}$ ✓ voltage stays the same ✓ statement of $Q = CV$ **and** Q doubles ✓	3	

Question	Marking guidance	Mark	Comments
05.3	Idea that an equal number of electrons is removed from the positive plate as is deposited onto the negative plate✓	1	Condone idea that electrons transferred from +ve plate to –ve plate (through cell)

Question	Marking guidance	Mark	Comments
05.4	Q stays the same ✓ as the capacitor is isolated OR charge cannot flow ✓ The capacitance halves AND reference to $E = \frac{Q^2}{2C}$ leading to energy doubles ✓	3	Note: if another version of the energy equation is used, eg $E = \frac{1}{2}CV^2$, only award full marks if the candidate states that V doubles MP3 is dependent on MP1 Allow 2 marks for a reasoned qualitative argument not justified by equations, ie work has to be done by external system to separate the + and – plates. ✓ Some energy must be stored in the capacitor so the energy stored increases. ✓

Question	Marking guidance	Mark	Comments
05.5	Idea that (energy is conserved because) the gain in stored energy is provided by the work done in pulling apart the plates ✓	1	

Total		**9**

Question	Marking guidance	Mark	Comments
06.1	Component of its velocity perpendicular to field ✓	1	Accept 'not moving parallel to' magnetic field Reject idea that motion must be perpendicular to the field

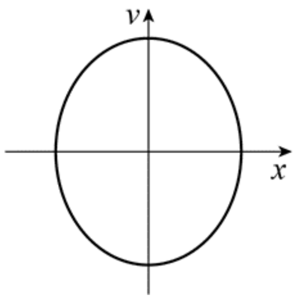
Question	Marking guidance	Mark	Comments
06.2	Equates expressions for centripetal force and magnetic force ✓ $p = mv$ substituted and convincing rearrangement ✓	2	Eg $mv^2/r = Bqv$

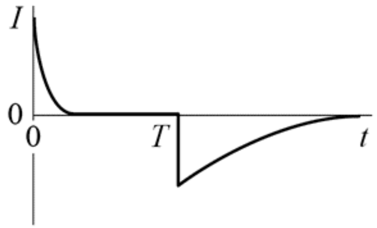
Question	Marking guidance	Mark	Comments
06.3	Particle loses some of its kinetic energy (to the gas molecules as it travels) ✓ Particle's velocity/momentum decreases ✓ Radius is directly proportional to the velocity/momentum ✓	3	For MP3, accept radius decreases as momentum decreases if supported with equation

Question	Marking guidance	Mark	Comments
06.4	Evidence of determination of a value of the initial radius by direct measurement ✓ Use of $r = mv/Bq$ (condone POT) ✓ Determines mv in range 1.0×10^{-21} ($\mathrm{kg\ m\ s^{-1}}$) to 1.2×10^{-21} ($\mathrm{kg\ m\ s^{-1}}$) ✓	3	Evidence must be seen on Figure 11 Give 2 marks max for diameter used instead of radius 2sf max for MP3 This tolerance is adjusted for non-standard printed scripts

Question	Marking guidance	Mark	Comments
06.5	Up to two correct statements and one correct corresponding reason ✓✓✓	3	Gamma photon is neutral or not very ionising (in this medium) because there is no track the charges of the two particles produced are opposite because the spirals are in opposite directions the two particles produced have same initial momentum as the tracks have similar radii (it must be clear which particles are being referred to, which can be implied by describing the track)

Total		**12**

Question	Key	Answer
07	**D**	time period of rotation of m
08	**C**	
09	**D**	$4k \qquad 16E$
10	**C**	$g \sin \theta$
11	**C**	$3\pi^2 G R^4 \rho^2$
12	**A**	$3.7\ \mathrm{N\ kg^{-1}}$
13	**B**	$\dfrac{4\pi\varepsilon_0 G A m_e M_n}{Ze^2}$
14	**B**	$10\ \mathrm{V}$

15	**A**	
16	**B**	$RC \ln \frac{3}{2}$
17	**A**	$\mathrm{N\ m\ A^{-1}}$
18	**C**	down the page into the page
19	**A**	$Bv = E$
20	**D**	0
21	**C**	**2** and **3**