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PHYSICS

PH03

Unit 3 Fields and their consequences

Mark scheme

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236XPH03/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.

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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	Correctly resolves horizontally or vertically ✓ Successfully resolves horizontally to give $\frac{mv^2}{r} = R\sin\theta$ AND vertically to give $mg = R\cos\theta$ ✓ Divides $\frac{mv^2}{r} = R\sin\theta$ by $mg = R\cos\theta$ and rearranges convincingly ✓	Allow full marks from a correct force diagram approach. If no other mark awarded MP1 for $mg\ tan\theta = mv^2 \div r$	3	1 AO1 1 AO2 1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	(Uses $u = \sqrt{rgtan\theta}$ to find) the velocity of **Q** = $58(.1)$ (m s^{-1}) ✓ Uses $t = \frac{s}{v}$ and $s = \pi r$ to find one correct time OR $\omega = \frac{v}{r}$ to find one correct angular speed ✓ All correct plus reasoned conclusion that **Q** passes **B** first ✓	**P**: $20(.1)$ (s) **Q**: 19.6 (s) $\omega_P = 0.156$ (rad s^{-1}) $\omega_Q = 0.160$ (rad s^{-1}) Expect to see a reference to the different times in MP3	3	1 AO1 1 AO2 1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	Clear attempt to take moments ✓ Recognises that $R_2 = mg$ OR $F_2 = \frac{mv^2}{r}$ when speed $= V$ ✓ Uses both $R_2 = mg$ and $F_2 = \frac{mv^2}{r}$ plus clear manipulation ✓	Each term must be a force x a distance expect to see $R_2 \frac{w}{2} = F_2 h$ but accept additional moments terms for MP1	3	1 AO2 2 AO3
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	(Magnitude of the resultant) force (acting on the body) is proportional to its displacement (from its equilibrium position) ✓ and is always directed towards the equilibrium position ✓	Accept acceleration for force. Accept 'in opposite direction to displacement'	2	2 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Out of the page ✓ Reference to Fleming's left-hand rule ✓	Condone 'to the right' if the candidate is clearly referring to **Figure 6** Do not condone "upwards" for "out of page." Accept "FLHR" or "left hand rule"	2	1 AO1 1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	Use of $F = ma$ or $l = 2\pi rN$ ✓ Use of $F = BIL$ ✓ 0.81 (T) ✓	evidence for MP2 can be seen as values 4.2(N) or 3.0(m) by substitution or manipulation	3	1 AO1 2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Use of $a_{max} = \omega^2 A$ ✓ $2.0(3) \times 10^{-4}$ (m) ✓	Ignore any minus sign	2	1 AO1 1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.5	(Use of $v = \omega A$ leading to) 0.33 (m s^{-1}) ecf from **02.4** ✓		1	1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.6	Minus cos graph shown for $1\frac{1}{2}$ cycles ✓ 3.8×10^{-3} (s) shown after 1 cycle and candidate's value from **02.5** shown on ordinate ✓		2	2 AO3
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	$\frac{GMm}{r^2} = mrw^2$ OR $\frac{GMm}{r^2} = \frac{mv^2}{r}$ seen ✓ Uses $T = \frac{2\pi}{\omega}$ and 24×3600 (s) ✓ Substitution into a relevant equation for r✓ Subtracts radius of Earth from their orbital radius to get 3.59×10^7 m ✓	Do not allow use of $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$ without derivation for MP1 allow MP2 for the correct substitution of T into the Kepler equation. Allow speed = circumference ÷ time period Expect to see $4.23 \times 10^7 - 6.37 \times 10^6$ (m) Answer to at least 3sf Accept answer in km	4	2 AO1 2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Equation that would give the value for v✓ 3070 (m s^{-1}) to at least 3 sf with some supporting evidence✓	e.g. for MP1 $\frac{GMm}{r^2} = \frac{mv^2}{r}$ OR $v = \omega r$ OR $v = \frac{2\pi r}{T}$ Allow a value rounds to 3070 or 3080	2	1 AO1 1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Attempts to use $E_p = -\frac{GMm}{r}$ OR $V = -\frac{GM}{r}$ and $E_p = -mV$ with their r ✓ Uses $E_k = \frac{1}{2}mv^2$ with their v ✓ Combine E_p and E_k to give an answer that rounds to -1.8×10^9 (J)✓	Condone POT errors in MP1 and MP2 Expect to see $E_p = (-)3.59 \times 10^9$ (J) Condone use of orbital height instead of orbital radius for this mark. Do not accept $r = 3.59 \times 10^7$ (m) Expect to see $E_k = 1.79 \times 10^9$ (J) Condone absence of minus sign for in MP3	3	1 AO1 2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Idea that the rocket already has max speed / velocity / KE at equator due to rotation ✓ Idea that easterly because this is the direction of its orbit ✓ Idea that orbits above equator (so reduced need for manoeuvring) ✓		3	1 AO2 2 AO4
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Correct data extraction: **Q** $(130, 1040)$ and **R** $(370, -1160)$ ✓ leading to answer that rounds to 9.2 (m s^{-2}) ✓	Condone a consistent misreading on the velocity scale in MP1 Allow ±half a grid square from each reading Condone minus sign	2	1 AO2 1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Idea that the astronaut weighs (slightly) less at altitude (because gravitational field strength is lower) ✓	Treat references to **figure 10** as neutral	1	1 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Idea that the astronaut is accelerating at the same rate (approximately) as g ✓	Treat references to **figure 10** as neutral Accept the statement that the astronaut is in freefall. Condone "free falling" for freefall Accept idea that the reaction force on the astronaut is zero AND the spacecraft is in freefall	1	1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Between **P** & **Q** the sensation of the astronaut's weight is increasing. ✓ Between **R** & **S** the sensation of weight is decreasing (back to value of weight on the ground) ✓	In either case, withhold the mark for the idea that weight is less than on the ground. Condone "going up" for "between **P** & **Q**" Condone "going down" for "between **R** & **S**" If no other mark awarded give MAX 1 mark for general idea that (in both cases) the astronaut's sensation of weight is greater (than their weight on the ground)	2	1 AO1 1 AO2
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Uses $e^{\text{intercept}}$ or correctly reads intercept as 18.12 ✓ 7.4×10^7 (Bq) ✓	Evidence for MP1 may be seen on the graph Allow range of 18.11 to 18.13 18.11 gives 7.33×10^7 (Bq) 18.13 gives 7.48×10^7 (Bq)	2	1 AO2 1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Attempts to find gradient using at least half the length of the line ✓$_1$ Uses $t_{\frac{1}{2}} = (-)\ \frac{0.693}{\text{gradient}}$ ✓$_2$ $3.6(1) \times 10^5$ (s) ✓$_3$	Attempt to find either gradient gets MP1 but expect to see 1.92×10^{-6} s for the correct gradient. Alternative for MP1 and MP2 Evidence of halving the initial activity (expect to see $3.7\text{x}10^7$ (Bq)) ✓$_1$ Evidence of ln(initial activity ÷ 2) (expect to see 17.43) ✓$_2$	3	2 AO2 1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Any **two** from: ✓✓ • uses $A = \lambda N$ • divides by 6.02×10^{23} • multiplies by 0.131 Then: 5.2×10^{-12} kg ✓	$A = 2.4 \times 10^{13}$ No. of moles $= 3.8 \times 10^{-11}$ Accept multiplication by 131 to give answer in g if stated	3	1 AO1 2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Only gamma rays observed ✓ as beta absorbed by body tissue / has weak penetrating power AND neutrinos very difficult to detect ✓		2	1 AO1 1 AO3
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Uses $Q = CV$ and $C = \frac{\varepsilon_0 A}{d}$ ✓ Uses $E = \frac{V}{d}$ ✓ 1.3×10^{-9} (C) ✓	Candidate who quotes $Q = \varepsilon_0 A \frac{V}{d}$ gets MP1 Using $Q = A\varepsilon_0\varepsilon_r E$ gets MP2 Condone missing ε_r Accept 1sf answer if 1.3×10^{-9} (C) is seen in working.	3	3 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Idea that polarised molecules or dipoles line up with the field (in opposition to it) ✓ Charge remains constant so pd decreases (because the total electric field between the plates decreases) OR Pd remains constant so charge must increase ✓	Accept “net field strength decreases” for “pd decreases.”	2	2 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Uses $E = \frac{1}{2}CV^2$ OR uses $E = VIt$ to calculate one correctly ✓ Capacitor stores 450 J and battery stores 13 000 J. So battery / **Z** stores more energy ✓		2	1 AO1 1 AO2

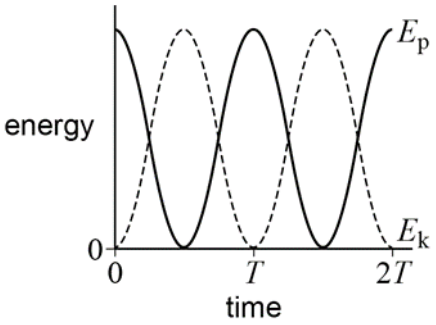
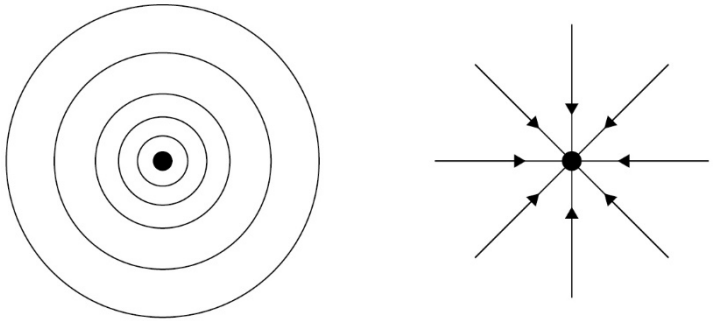
Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Terminal pd of capacitors fall as they discharge ✓	Accept current or pd falls as capacitor discharges OR that additional circuitry would be needed to prevent this (e.g. op amp)	1	1 AO2
Total			**8**	

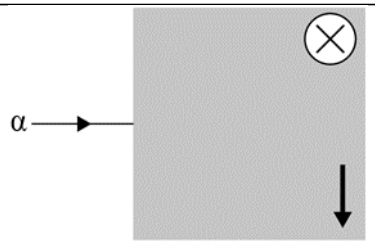
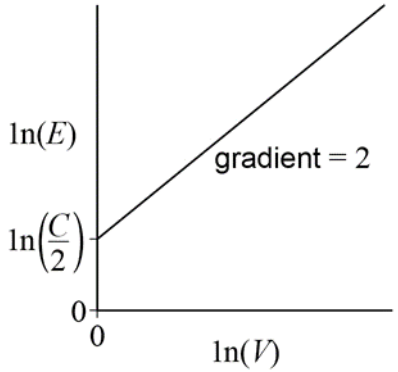
Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	There is no electric field within the drift tube ✓	Accept the potential is constant inside the tube OR the pd across the tube is zero	1	1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Uses $\Delta W = Q\Delta V$ or multiplies $42\ \text{kV}$ by 30 ✓ to give $2.0(2) \times 10^{-13}$ (J) ✓	For full marks there must be at least a subject for the equation. Condone 1.95×10^{-13} (J) if the candidate thinks that there are 29 gaps.	2	1 AO1 1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Uses $E_k = \frac{1}{2}mv^2$ ✓ Use of $\frac{1}{f} = 2.0 \times 10^{-7}$ s ✓ 1.55 or 1.6 (m) ✓	Expect to see $v = 1.5(48) \times 10^7\ (\text{ms}^{-1})$ Allow MP3 for use of 1.95×10^{-13} (J) to give $1.5(3)$ (m)	3	1 AO1 2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	2 gamma photons (moving in opposite directions) ✓ Each with energy (of at least) 1.51×10^{-10} J ✓	Evidence for MP1 can be seen in a diagram. Condone "gamma rays" for "gamma photons"	2	1 AO2 1 AO4
Total			**8**	

Question	Key	Answer	AO
08	B	$-\omega A\sin\omega t$	1 AO3
09	A		1 AO3
10	A	$m_1 = \frac{m_2}{9}$	1 AO2
11	B	$R < P < Q$	1 AO3
12	C		1 AO2

13	**D**		1 AO3
14	**A**	q, B and m	1 AO3
15	**A**		1 AO3
16	**B**	43 nF	1 AO3
17	**B**	changing changing	1 AO2
18	**D**	**3** **2**	1 AO4
19	**C**	**2** and **3** only	1 AO2
20	**D**	0.0071 V	1 AO2

21	**A**	0.61 2750	1 AO2
22	**D**	44 kA	1 AO2