A-LEVEL
Physics
PHYA4 – Fields and Further Mechanics
Mark scheme

2450
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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 Assessment Writer.

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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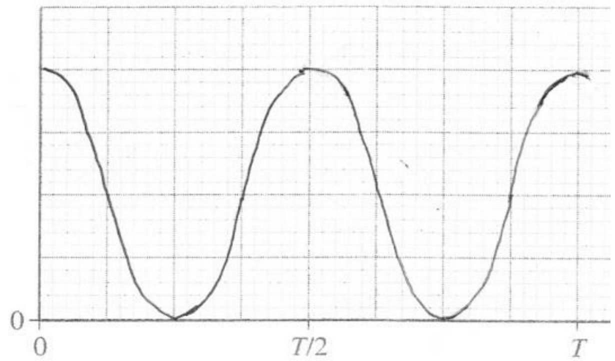
Section A

1	**C**	14	**D**
2	**C**	15	**B**
3	**A**	16	**D**
4	**A**	17	**B**
5	**D**	18	**C**
6	**B**	19	**A**
7	**A**	20	**B**
8	**C**	21	**C**
9	**D**	22	**C**
10	**B**	23	**A**
11	**D**	24	**D**
12	**D**	25	**B**
13	**B**		

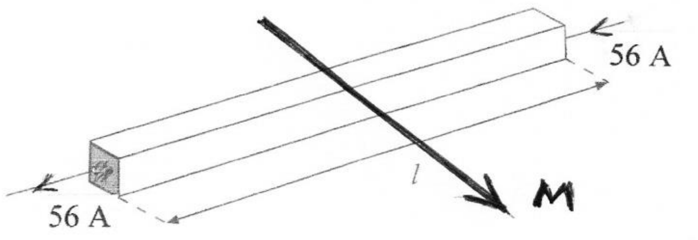
Question	Answers	Additional Comments/Guidance	Mark	ID details
1(a)	kinetic energy $\rightarrow$ gravitational potential energy $\rightarrow$ kinetic energy $\rightarrow$ gravitational potential energy $\rightarrow$ kinetic energy ✓✓ energy lost to surroundings in overcoming air resistance ✓	Allow ke and gpe for full marks. If *gravitational* is omitted, max 1 from first two marks. If cycle shows correct sequence but is incomplete, max 1 from first two marks. If starting point is incorrect, none of first two marks.	max 2	
1(b)(i)	period $T = \left(\frac{64}{20}\right) = 3.2\text{ s}$ ✓ use of $T = 2\pi\sqrt{\frac{l}{g}}$ gives length $l = \left(\frac{T^2 g}{4\pi^2}\right) = \frac{3.2^2 \times 9.81}{4\pi^2}$ ✓ giving distance from pt of support to c of m l = 2.54 = 2.5 (m) ✓ answer to **2SF** only ✓	SF mark is independent, but 2.54 **or** 2.5 gains third mark.	4	
1(b)(ii)	($E_k =$) $mg\Delta h$ stated or used ✓ gives E_k of girl at lowest point (= 21 × 9.81 × 0.28) = 58 (57.7) (J) ✓		2	

Question	Answers	Additional Comments/Guidance	Mark	ID details
1(b)(iii)	½ mv^2 = 57.7 gives max speed of girl $v = \sqrt{\frac{2\times 57.7}{21}}$ = 2.3(4) (m s^{-1}) ✓ [**alternatively** A^2 = (5.08 – 0.28) × 0.28 gives A = 1.16 (m) and $v_{max} = 2\pi f A = \left(\frac{2\pi}{3.2}\right)\times 1.16$ = 2.3 (2.28) (m s^{-1}) ✓]	Use of 58J gives 2.4 m s^{-1}	1	
1(c)	graph drawn on **Figure 2** which: • has maxima of similar size (some attenuation allowed) at t = 0, T/2 and T ✓ • shows E_p = 0 [**or** any consistent minimum value] at t = T/4 and 3T/4 ✓ • is of the correct general shape ✓ 	1st point: maxima to be ± 1 square of t axis 2nd point: 0 values to be ± 1 square of t axis	3	
Total			**12**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
2(a)	ticks placed in 2nd and 5th boxes **only** ✓		1	
2(b)(i)	$G\dfrac{Mm}{(R+h)^2} = m\omega^2(R+h)$ ✓	Correct symbols must be used.	1	
2(b)(ii)	use of $\omega = \dfrac{2\pi}{T}$ ✓ gives $\dfrac{GM}{(R+h)^3} = \dfrac{4\pi^2}{T^2}$, rearrange for result ✓		2	
2(b)(iii)	limiting case is orbit at zero height i.e. h = 0 ✓ $T^2 = \left(\dfrac{4\pi^2 R^3}{GM}\right) = \dfrac{4\pi^2 \times (6.4\times10^6)^3}{6.67\times10^{-11}\times6.0\times10^{24}}$ ✓ T = 5090 s ✓ (=85 min)	1st mark requires suitable statement: use of h = 0 in equation is not sufficient.	3	
2(c)	satellite's speed increases ✓ loses (gravitational) potential energy but gains kinetic energy ✓ [**or** because $v^2 \propto \dfrac{1}{r}$ from $\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$ ✓]		2	
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3(a)(i)	force is perpendicular to (initial) velocity [**or** force acts in direction of electric field] ✓		1	
3(a)(ii)	initial velocity component is maintained ✓ α particle is accelerated in direction perpendicular to initial velocity [**or** in direction of E field] ✓ parabolic path ✓		max 2	
3(b)(i)	force is in same direction as initial velocity ✓	**or** in direction of E field	1	
3(b)(ii)	α particle is accelerated [**or** its speed increases] along the same straight line✓	**or** in direction of E field	1	
3(c)(i)	$E\left(=\frac{V}{d}\right)=\frac{130}{41\times10^{-3}}$ = 3170 (V m^{-1})	Must see 3170 (i.e. minimum 3SF) to award mark i.e. not for 3200 alone.	1	
3(c)(ii)	F (= EQ) = 3170 × 1.60 × 10^{-19} = 5.1 (5.07) × 10^{-16} (N)	ecf available for use of answer from (i) or from 3200.	1	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3(c)(iii)	E_k gained (= E_p lost) = eV ✓ = $1.60 \times 10^{-19} \times 130 = 2.1\ (2.08) \times 10^{-17}$ (J) ✓ [**or** E_k gained = Fd ✓ = $5.07 \times 10^{-16} \times 41 \times 10^{-3} = 2.1\ (2.08) \times 10^{-17}$ (J) ✓] [**or** use of $F = ma$ and $v^2 = u^2 + 2as$ gives $a = 5.57 \times 10^{14}$ (m s^{-2}) and $v^2 = 4.57 \times 10^{13}$ (m^2 s^{-2}) ✓ E_k gained = ½ mv^2 = ½ × $9.11 \times 10^{-31} \times 4.57 \times 10^{13}$ = $2.1\ (2.08) \times 10^{-17}$ (J) ✓]	ecf available from errors in earlier parts	2	
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4(a)	current must be perpendicular to magnetic field ✓	Condone conductor perpendicular to B.	1	
4(b)(i)	mass of bar $m = (30 \times 10^{-3})^2 \times 2700 \times l$ ✓ (= 2.43 l) weight of bar (= mg) = 2.43 $l \times 9.81$ ✓ (= 23.8 l) $mg = BIl$ [**or** weight = magnetic force] ✓ 23.8 $l = B \times 56 \times l$ gives $B = 0.43$ (0.425) ✓ unit: T [**or** tesla] ✓	Unit mark is independent. (Accept Wb m^{-2})	5	
4(b)(ii)	arrow (labelled **M)** in correct direction drawn on **Figure 4** ✓ 		1	
Total			**7**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5(a)(i)	current $\left(=\frac{P}{V}\right)=\frac{750\times10^3}{25\times10^3}=30$ (A) ✓		1	
5(a)(ii)	wasted power $\left(=I^2R\right)=30^2\times20$ = 1.80 × 10^4(W) (18.0 kW) ✓ power output from cables = 750 – 18 = 732 (kW) ✓ [**or** voltage drop along cables (= $I\,R$) = 30 × 20 = 600 (V) ∴ output voltage = 25000 – 600 = 24400 (V) ✓ power output = $I\,V$ = 30 × 24400 = 732 (kW) ✓]	Allow ecf from 15A, or from an incorrect current value following an AE in (i).	2	
5(a)(iii)	efficiency $\left(=\frac{P_{out}}{P_{in}}\right)=\frac{732}{750}\times100$ = 98 (97.6) (%) ✓	Allow ecf from incorrect power value in (ii).	1	
5(b)(i)	step-up: secondary coil has more turns than primary step-down: primary coil has more turns than secondary [**or** any equivalent answer] ✓	Condone *either* statement for this mark. Insist on comparison between primary and secondary turns.	1	
5(b)(ii)	to reduce heating (I^2R) loss [**or** energy/power/copper loss] ✓ (because) primary current is greater than secondary current ✓ R is reduced (by use of thicker wire) ✓		max 2	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5(c)	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. *The candidate describes accurately the measures used to limit the power losses, referring to the use high voltages (to reduce the current) and of low resistance cables (to limit $I^2 R$ losses). The answer shows appreciation that changing the voltage usually requires the use of transformers, which operate only with ac, and/or that the transformation of dc requires more complex methods. The reasons for reducing the voltage in stages are given coherently in the answer.* **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary is used incorrectly. The form and style of writing is less appropriate. *The candidate is less clear about measures taken to limit the power losses. The candidate is likely to appreciate the need*	A **high level** answer must include 1. References to all three bullet points. 2. A good understanding of energy losses from cables and the factors that affect them. 3. A good understanding of the use of ac and transformers to change voltages. 4. Appreciation of the insulation / safety / economic issues that make staged voltage reduction necessary. An **intermediate level** answer must include 1. References to at least two bullet points. 2. Some understanding of energy losses from cables and the factors that affect them **or** 3. Some understanding of the use of ac and transformers to change voltages **or** 4. Some understanding of stepped voltage reduction. A **low level** answer must include 1. Reference to at least one bullet point. 2. A little understanding of **either** the energy losses from cables **or** the use of ac and transformers to change voltages.	6	

	for the use of transformers to change voltages and their reliance upon ac. The reasons for reducing the voltage in stages may be known superficially, or may not be known at all. **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. *The candidate gives a very superficial account, which shows little understanding of how energy losses are reduced, of the reasons for preferring ac to dc, or of the staged reduction of voltages.* **Incorrect, inappropriate or no response: 0 marks** The answer presented refers to unrelated, incorrect or inappropriate physics. **The explanation expected in a competent answer should include a coherent selection of the following points.** • current in cables causes joule heating (or I^2R losses) • resistance of cables should be as low as possible • losses are reduced if current in cables can be reduced • current can be reduced (for same power) if V is increased • the higher the voltage, the smaller the proportion of the input power that is wasted • voltages are changed by transformers, which work with ac but not with dc • this is because inducing an emf requires the flux linkage through the secondary to be changing • ac generation and transmission is therefore preferred • high voltages introduce insulation problems and safety issues			

	• for safety, voltage must be reduced as the supply reaches the consumers • high voltage distribution systems are installed most economically using overhead cables • lower voltages are usually required for underground cables • the transformation is staged so that the highest acceptable voltage is used for as much of the distance as possible • transformers also cause energy losses because they are not perfectly efficient • features are incorporated in the design of transformers to reduce losses from them			
Total			**13**	