



*Rewarding Learning*

**ADVANCED  
General Certificate of Education  
2019**

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## **Physics**

**Assessment Unit A2 2**

*assessing*

**Fields, Capacitors and Particle Physics**

**[APH21]**

**FRIDAY 24 MAY, MORNING**

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**MARK  
SCHEME**

## Subject-specific Instructions

In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are not shown. It is not necessary to quote correct units for intermediate numerical quantities.

Note that this “correct answer” rule does not apply for formal proofs and derivations, which must be valid in all stages to obtain full credit.

**Do not reward wrong physics.** No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation. However, answers to later parts of questions that are consistent with an earlier incorrect numerical answer, and are based on physically correct equation, must gain full credit. Designate this by writing **ECF** (Error Carried Forward) by your text marks.

The normal penalty for an arithmetical and/or unit error is to lose the mark(s) for the answer/unit line. Substitution errors lose both the substitution and answer marks, but  $10^n$  errors (e.g. writing 550 nm as  $550 \times 10^{-6}$  m) count only as arithmetical slips and lose the answer mark.

			AVAILABLE MARKS				
1	(a)	1 C (of charge) per volt	[1] [1]	[2]	9		
		(b) (i)	equal charge on each $C_1V_1 = C_2V_2$ 330 $\mu\text{F}$	[1] [1] [1]		[3]	
	Alternative: $Q = 2.64 \times 10^{-3}$ or $C = \frac{Q}{8}$ or subs of C values with Q to get V						
	(ii)		220 $\mu\text{F}$	[1]			
		$\frac{1}{2}CV^2$	[1]				
		Subs (ecf C value)	[1]				
		0.016 J	[1]	[4]			
		alternative $\frac{1}{2}CV^2$ $0.5 \times 660 \times 4^2$ $0.5 \times 330 \times 8^2$ 0.016 J	[1] [1] [1] [1]				
	2	(a)	region/volume/space where body with particular property or nature experiences a force (accept listing all properties)	[1] [1]		[2]	7
			(b) (i)	Fig. 2.1 +2 $\mu\text{C}$ charge		[1]	
Fig. 2.2 4 kg mass		[1]		[2]			
(ii)		radial field weakens as moves away/spacing increases strength decreases with $1/r^2$ (gets [2]) accept both have infinite range field around mass only attractive, around charge attractive/repulsive accept shield against E field, not g field		[1] [1] [1] [1]	[3]		
3		(a)	$F = k Q_1Q_2/r^2$	[1]		8	
	subs in one equation		[1]				
	sum of 2 forces		[1]				
	$1.6 \times 10^5 \text{ N}$		[1]				
	direction right		[1]	[5]			
	SE: $9.6 \times 10^4$ [4] with correct direction, $4 \times 10^4$ with correct direction [4]						
	(b)	to the left of -2 $\mu\text{C}$ outside the charges for balancing in terms of charge/to get 2 forces in opposite directions to the left of 2 $\mu\text{C}$ to balance in terms of magnitude/further away from the 8 because it is largest charge	[1] [1] [1]	[3]			

4 (a)  $eV$  or  $\frac{1}{2}mv^2$  [1]  
 equating  $eV = \frac{1}{2}mv^2$  [1]  
 correct subs with  $1.6 \times 10^{-19}$  and  $9.11 \times 10^{-31}$  [1] [3]

(b) correct subs in equation [1]  
 $m = 9.31 \times 10^{-31}$  kg [1]  
 difference in  $m$  values or  $m/m_e = 1.022$  [1]  
 2.2% increase [1] [4]  
 SE: 2.15% from incorrect % calc [3], 4.5% or 12.3% [3]

(c) particles accelerated in electric fields/between electrodes/by p.d/between cavities  
 repelled from one electrode and attracted towards the next  
 frequency (of a.c. supply) increases as  $v$  increases  
 (dipole) magnets cause particles to follow (circular) path  
 mag field strength increases as  $v$  increases  
 (quadrupole) magnets focus beam

Response	Marks
Candidates identify clearly <b>5 or 6</b> of the points above relating to the operation of a synchrotron. There is widespread and accurate use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are excellent. They use the most appropriate form and style of writing. Relevant material is organised with clarity and coherence.	[5]–[6]
Candidates identify clearly <b>3 or 4</b> of the points above relating to the operation of a synchrotron. Presentation, spelling, punctuation and grammar are sufficiently competent to make meaning clear. They use appropriate form and style of writing. There is good reference to scientific terminology.	[3]–[4]
Candidates identify clearly <b>1 or 2</b> of the points above relating to the operation of a synchrotron. There may be some errors in their spelling, punctuation and grammar but form and style are of a satisfactory standard. They have made some reference to specialist terms.	[1]–[2]
Response is not worthy of credit.	[0]

[6]

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5 (a) Example of a lepton, e.g. electron [1]  
 Example of a hadron, e.g. proton, neutron [1]  
 hadrons feel strong nuclear force (accept strong interaction), leptons do not [1]  
 hadrons are composite, leptons fundamental [1] [4]

(b) (proton positive,  $\bar{\nu}$  and  $n$  neutral,  $X$  is positive) +1 [1]  
 ( $\bar{\nu}$  has lepton no  $-1$ ,  $p$  and  $n$  zero,  $X$  is anti-lepton)  $-1$  [1]  
 ( $p$  and  $n$  are baryons,  $\bar{\nu}$  is not,  $X$  not a baryon) 0 [1]  
 $X$  is a positron [1] [4]

(c) (i)  $n \rightarrow p + e^- + \bar{\nu}_e$  (or  $d \rightarrow u + e^- + \bar{\nu}_e$ ) [1]

(ii) weak nuclear force/weak interaction [1]

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				AVAILABLE MARKS		
6	(a) (i)	F = Eq or F = Vq/d	[1]	[3]	14	
		F = Bqv (accept Bll)	[1]			
		Correct directions, F <sub>E</sub> upwards, F <sub>B</sub> downwards	[1]			
	(ii)	forces equated <b>and</b> V/d = Bv or E = Bv	[1]	[3]		
		subs	[1]			
		2.3 × 10 <sup>5</sup> ms <sup>-1</sup>	[1]			
	(b) (i)	out of the page		[1]		[5]
		(ii)	radius will vary with mass of particle/ion (as q, B, v constant)	[1]		
			greater mass strike detector nearer the bottom (or vice versa)	[1]		
		(iii)	B = mv/rq or Bqv = $\frac{mv^2}{r}$	[1]		
r = 2 × 10 <sup>-2</sup> m			[1]			
m = 6u			[1]			
subs			[1]			
0.15T	[1]					
	SE: 9 × 10 <sup>25</sup> [4], 0.075 [4], 0.174 [4], 0.087 [3], 0.16 [3], 0.32 [4]					
7	(a) (i)	orbit above equator (of Jupiter)	[1]	[3]	14	
		same period/period of 1 day/same angular velocity	[1]			
		same direction	[1]			
	(ii)	$F = \frac{GMm}{r^2}$	[1]	[6]		
		$F_C = mr \left(\frac{4\pi^2}{T^2}\right)$	[1]			
		T in seconds (3.6 × 10 <sup>4</sup> )	[1]			
		correct subs into eqn	[1]			
		r = 1.61 × 10 <sup>8</sup> m	[1]			
		h = 8.9 × 10 <sup>7</sup> m	[1]			
	(iii)	v = 2πr/T or v = rω or v = $\sqrt{\frac{GM}{r}}$	[1]	[2]		
		subs to get v = 2.8 × 10 <sup>4</sup> ms <sup>-1</sup>	[1]			
(b)	g = GM/r <sup>2</sup>	[1]	[3]			
	4.89	[1]				
	W = mg = 1467 N	[1]				
	(or use of F <sub>C</sub> = W)					

			AVAILABLE MARKS	
8	(a)	sketch to include primary coil and secondary coil	[1]	
		(laminated iron) core	[1]	
		more turns in secondary coil	[1] [3]	
	(b) (i)	$N_s/N_p = I_p/I_s$	[1]	
		$0.045 \times 20 = 0.9 \text{ A}$	[1] [2]	
	(ii)	$P = I \times V$	[1]	
		output power = $22.5 \times 0.955 = 21.5 \text{ kW}$	[1]	
		$V = 477\,500 \text{ V}$		
		(or $22\,500/0.9 = 25\,000$ , $(25\,000 \times 20) \times 0.955 = 477\,500 \text{ V}$ ecf from 0.9 in (b)(i) if this method used) SE: $5 \times 10^5$ [2], $5.24 \times 10^5$ [2]	[1] [3]	
	(iii)	(Any 3 of 4)		
• flux leakage/loss		[1]		
• wind both coils on one limb of core/on top of each other		[1]		
• eddy currents in core cause heating		[1]		
• laminate core		[1]		
• (resistance) heating in coils		[1]		
• thicker/lower resistivity wire/coolant		[1]		
• hysteresis	[1]			
	(soft) iron	[1] [6]	14	
9	(a) (i)	Faraday's Law – induced emf is proportional to the rate of change of flux or equal to the rate of change of flux linkage/total flux	[1]	
		(ii) Lenz's Law – Direction of the induced effect is such that it opposes the change that is causing it	[1]	
	(b) (i)	time too short to take readings	[1]	
		(ii) leaving – moving quicker	[1]	
		rate of change increases	[1]	
		Induced N pole at top of coil as magnet approaches/repels on entry	[1]	
		Polarity reverses as magnet leaves/attracts on leaving	[1]	
		Direction of current/emf reverses	[1] [5]	
	(iii)	1. (both) peaks greater values/emf greater and (both) shorter times	[1]	
		2. peaks greater values (same time)	[1] [3]	
<b>Total</b>			<b>100</b>	