New Specification

Rewarding Learning

ADVANCED
General Certificate of Education
2018

Physics

Assessment Unit A2 2

assessing

Fields, Capacitors and Particle Physics

[APH21]

FRIDAY 8 JUNE, MORNING

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 550×10^{-6} m) count only as arithmetical slips and lose the answer mark.

						AVAILABLE MARKS
1	(a)	(i)	Time taken for voltage across capacitor to fall to 37% or 1/e of its initial value (accept charge/current)		[1]	
		(ii)	Switch S to position 1 (to fully charge capacitor; record V)	[1]		
			Switch S to position 2; (start stop-clock capacitor starts to discharge)	[1]		
			Record V in regular intervals	[1]	[3]	
			Use of I SE [–1], charging [0]/[2]			
	(b)	(i)	Plot V against t	[1]		
			Correct graph	[1]	[2]	
		(ii)	Determine time τ for V to fall to 37% of V_0	[1]		
			Repeat by determining time 2τ for V to fall to 14% (0.37 × 0.37) of V or a second 37% from different V_0	[1]		
			Calculate average value of τ	[1]	[3]	9

AVAILABLE MARKS

2 **(a)** Force of attraction [1]
Proportional to (product of) masses [1]
Inversely proportional to square of (mass) separation [1] [3]

(b) **(i)** $g = \frac{Gm_E}{r^2}$ eqn [1]

$r^2 = \frac{(6.67 \times 10^{-11}) \times (5.98 \times 10^{24})}{7.97}$ subs [1]

$r^2 = 5.00 \times 10^{13}$ m

$r = 7.07 \times 10^6$ m [1]

Orbital height = $(7.07 - 6.37) \times 10^6$

$= 7.04 \times 10^5$ m [1] [4]

(ii) $F = \frac{Gm_e m_s}{r^2}$ [1]

$F = m\omega^2 r$ or in terms of T [1]

$T^2 = \frac{4\pi^2 r^3}{Gm_e}$ [1]

$T^2 = \frac{4\pi^2 (7.07 \times 10^6)^3}{(6.67 \times 10^{-11}) \times (5.98 \times 10^{24})}$ subs [1]

$T^2 = 3.50 \times 10^7$ s [1]

T = 1.64 hours ecf T^2 or T [1] [6]

(iii) No. T for a geostationary satellite = 24 hours
or
No. Orbital height not equal to 3.59×10^7 m
or
No. Radius of orbit not equal to 4.23×10^7 m [1] 14

3 (a) (i)

Fundamental force	Exchange particle
Strong nuclear/interaction	Gluon
Weak interaction/nuclear	W^-, W^+, Z^0
Electromagnetic	Photon
Gravitational	Graviton

[4]

(ii) Hadrons feel the strong force, leptons do not [1]
Hadrons have a quark structure/are composite, leptons are fundamental particles/have no structure [1] [2]

(iii) Neutron: udd [1]

(iv) $d \rightarrow u + W^-$
$W^- \rightarrow e^- + \bar{\nu}_e$ [2]

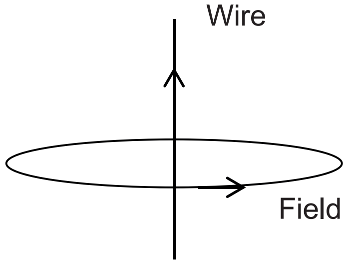
(b) Conservation of charge Q:
LHS = 0 + 1 = 1; RHS = 0 + 1 + 1 + (–1) = 1
Charge conserved [1]

Conservation of baryon number B:
LHS = 1 + 1 = 2; RHS = 1 + 1 + 1 + 0 = 3
Baryon number **not** conserved [1]

Reaction cannot happen. [1] [3]

AVAILABLE MARKS: 12

4 **(a)** Circular field [1]
Anticlockwise [1] [2]



(b) Down [1]

(c) **(i)**

I/A	m/g	F/N
0	76.83	
4.24	76.30	**0.0052**

Δm value [1] X 9.81 [1] 10^n [–1] [2]

(ii) $B = F/IL$ eqn [1]
$= 0.0052/(4.24 \times 5.0 \times 10^{-2})$ subs [1]
$= 0.0245$ [1] [3]
ecf from (i)

(iii) $\rho = \frac{RA}{L}$ eqn [1]
$R = V/I = 0.097\,\Omega$ [1]
$A = \pi r^2 = \pi \times (0.09 \times 10^{-3})^2 = 2.54 \times 10^{-8}\,m^2$ [1]
$\rho = 0.097 \times \pi \times (0.09 \times 10^{-3})^2/(5 \times 10^{-2})$
$= 4.92 \times 10^{-8}\,\Omega m$ [1] [4]

AVAILABLE MARKS: 12

AVAILABLE MARKS

5 (a) (i) T1: Step up
T2: Step down [1]

Construction:
- primary coil and secondary coil
- linked by a (laminated soft iron) core [2]

(ii) Indicative content
- a.c. input to primary coil V_p
- produces a (continually) changing magnetic flux
- which creates a changing flux in the secondary (linked by soft iron core)
- an a.c. output is induced across secondary V_s
- $N_s < N_p$
- $V_s < V_p$

Response	**Marks**
Candidates identify clearly **5–6** of the points above relating to how transformer T2 works to produce an appropriate output voltage to our homes. 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 **3 or 4** of the points above relating to how transformer T2 works to produce an appropriate output voltage to our homes. 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 **1 or 2** of the points above relating to how transformer T2 works to produce an appropriate output voltage to our homes. 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]

(b) lower current [1]

less energy lost as heat in cables or power lost = I^2R [1] [2] 11

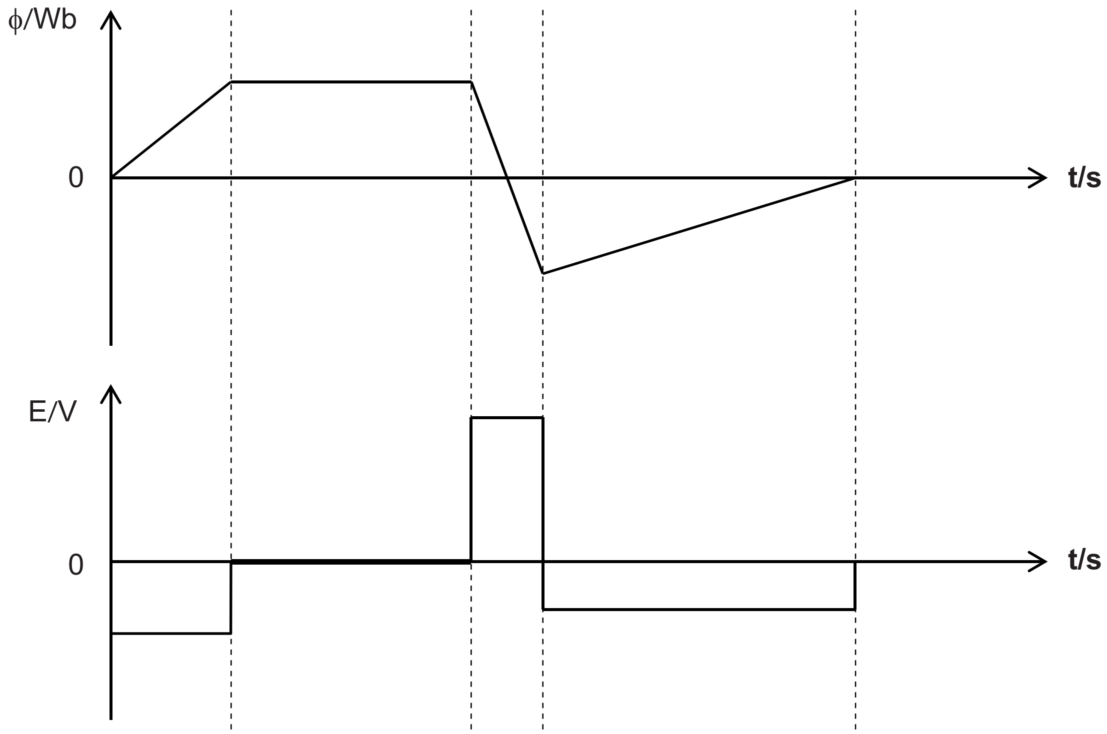
					AVAILABLE MARKS
6	**(a)**	Force on a charge	[1]		
		unit charge or 1 coulomb	[1]	[2]	
	(b) (i)	$F = 8.99 \times 10^9 \dfrac{(25 \times 10^{-6} \times 15 \times 10^{-6})}{2^2}$ or equation	[1]		
		$F_{Qz} = 0.84$ N	ans [1]		
		Towards left	[1]	[3]	
	(ii)	$E = k\dfrac{Q}{d^2}$			
		$E_{ZQ1} = k\dfrac{(25 \times 10^{-6})}{x^2}$, $E_{ZQ2} = k\dfrac{(15 \times 10^{-6})}{(2-x)^2}$ } either	subs [1]		
		$E_{ZQ1} = E_{ZQ2}$ equates	[1]		
		Elimination of k and rearrange to a correct quadratic or taking square root	[1]		
		$x = 1.13$	[1]	[4]	9

						AVAILABLE MARKS
7	**(a)**	**(i)**	Magnetic field provides centripetal force	[1]		
			strength is increased	[1]	[2]	
		(ii)	Electromagnets are cooled using liquid helium/to critical or transition temp	[1]		
			To reduce the resistance of the coils to zero	[1]		
			Increased I	[1]		
			Large magnetic field	[1]	[4]	
		(iii)	To maintain synchronous acceleration		[1]	
		(iv)	Their mass increases		[1]	
	(b)		$E = qV$	[1]		
			$= 1.6 \times 10^{-19} \times 8 \times 2 \times 10^{6}$			
			$= 2.56 \times 10^{-12}$ J	[1]		
			$= 16 \times 10^{6}$ eV	[1]		
			$(7 - 0.45) \times 10^{12} = 6.55 \times 10^{12}$ eV $(1.048 \times 10^{-6}$ J$)$	[1]		
			$\frac{6.55 \times 10^{12}}{16 \times 10^{6}} = 4.1 \times 10^{5}$	[1]	[5]	13

AVAILABLE MARKS

8 (a) (i) The magnitude of the induced e.m.f. is equal to the rate of change of flux linkage/proportional to the rate of change of flux [1]

(ii)



Horizontal line drawn where top graph sloped [1]
0 value where top graph is horizontal [1]
Relative magnitudes of horizontal lines consistent with top graph [1]
Positive slope leading to negative E and v.v. [1] [4]

(b) (i) Coil is perpendicular to field [1]
Magnetic flux through coil is maximum [1]
rate of change of flux = 0 [1] [3]
(Thus e.m.f. induced is zero)

(ii) f = 500/60 = 8.33 Hz [1]

(iii) $E_{Max} = BAN\omega$
$= 55 \times 10^{-3} \times 65 \times 10^{-4} \times 340 \times 2\pi \times 8.33$ [1]
$= 6.36$ V [1] [2] 11
ecf from (b)(ii)

						AVAILABLE MARKS
9	**(a)**	**(i)**	$E = V/d$ $= 1500/(30 \times 10^{-3})$ eqn or subs $= 50000\ \text{V m}^{-1}$	[1] [1]	[2]	
		(ii)	Calculate force due to field $F = qE$ $= 1.6 \times 10^{-19} \times 50000$ eqn or subs $= 8 \times 10^{-15}\ \text{N}$ ecf from **(i)**	[1] [1]	[2]	
		(iii)	Calculate acceleration experienced by electron $a = F/m_e = 8 \times 10^{-15}/9.1 \times 10^{-31} = 8.78 \times 10^{15}$ ecf from **(ii)**		[1]	
	(b)	**(i)**	Calculate time within field $s = ut + \frac{1}{2}at^2$ $15 \times 10^{-3} = 0 + (\frac{1}{2} \times 8.78 \times 10^{15}).t^2$ subs $t = 1.84 \times 10^{-9}$ ecf from **(iii)**	[1] [1] [1]	[3]	
		(ii)	Calculate speed of electron entering field $v = s/t = 175 \times 10^{-3}/1.84 \times 10^{-9} = 9.47 \times 10^{7}\ \text{m s}^{-1}$ ecf from **(b)(i)**		[1]	9
					Total	**100**