



**ADVANCED**  
**General Certificate of Education**  
**2011**

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## **Physics**

**Assessment Unit A2 2**  
*assessing*  
**Fields and their Applications**

**[AY221]**

**MONDAY 6 JUNE, AFTERNOON**

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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

		AVAILABLE MARKS
1 (a) A region where an object with mass experiences a force	[1]	
(b) $g = GM/r^2$ $9.81 = 6.67 \times 10^{-11}M / (6.37 \times 10^6)^2$ Subs $M = 5.97 \times 10^{24}$ (kg)	[1] [1] [1] [3]	
(c) (i) 86400 (s)	[1]	
(ii) $F = m\omega^2 r$ $(F = 2.11 \times 10^3 \times (4\pi^2 / 86400^2) \times)$ ecf (i) $(3.58 \times 10^7 + 6.37 \times 10^6)$ Subs Don't penalise again if km $\rightarrow$ m $F = 471$ (N)	[1] [1] [1] [3]	
(iii) $\frac{R_1^3}{T_1^2} = \frac{R_2^3}{T_2^2}$ Don't penalise again if no $(r_E + r_0)$ $T^2 = 1.79 \times 10^5$ (s)	[1] [1] [2]	10
2 (a) Force per unit charge	[1] [1] [2]	
(b) (i) $E = kQ/r^2$ Subs $E = 5.14 \times 10^{15}$	[1] [1] [1] [3]	
(ii) (1) $F = Eq$ or subs $F = 8.22 \times 10^{-4}$ (N)	[1] [1] [2]	
(2) Attractive; unlike charges (attract) (negative force)	[1] [1]	8

				AVAILABLE MARKS
3	(a)	Charging or discharging working circuit containing a capacitor and resistor	[1]	
		Correctly positioned ammeter or voltmeter	[1]	
		Correct circuit symbols (PSU, capacitor, resistor, meter)	[1]	
		Mark independently of circuit	[3]	
	(b)	(i) Voltage or current measured with time	[1]	
		Stopwatch required	[1]	
		(ii) Method 1: Discharging or charging		
		Plot natural log voltage or current (on y-axis), time (on x-axis)	[1]	
		Measure gradient of graph	[1]	
		Time constant = $1/\text{gradient}$	[1]	
		or		
		Method 2: Discharging or charging		
		Plot voltage or current on y-axis, time on x-axis	[1]	
		CR = time to rise to 0.63 final value or fall to 0.37 maximum value	[1]	
		Repeat + average	[1]	
		or		
		Method 3: Direct measurement		
		CR = time to rise to 0.63 initial value or fall to 0.37 maximum value	[1]	
4	(a)	(i) Arrow on wire pointing up	[1]	8
		(ii) Electronic scale reads a HIGHER value	[1]	
		Wire exerts a downwards force of equal magnitude on the <i>magnet assembly</i> (not scales)	[1]	
			[2]	
	(b)	(i) Reverse the direction of the current or field	[1]	
		(ii) $F = mg = 1.28 \times 10^{-3} \times 9.81$ Eqn or subs	[1]	
		$= 0.01256 = 0.0126$	[1]	
			[2]	
	(c)	(i) Force = $0.01 \text{ N} \pm 0.005 \text{ N}$ ecf (i)	[1]	
		(ii) $F = Bil$ or $BI = 0.0025$	[1]	
		$B = 0.0025/0.12 = 0.021 \text{ (T)}$	[1]	9
			[2]	

- 5 (a) Heat produced by eddy currents in the core is reduced by laminating core [1]  
 Magnetic flux leakage reduced by a continuous core [1]  
 Heat produced in wires reduced by selecting low resistance wire [1]  
 Heat generated in core by continual magnetising and demagnetising reduced by manufacturing the core from iron [1] [4]

### Quality of written communication

#### 2 marks

The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well structured. There are few errors of grammar, punctuation and spelling.

#### 1 mark

The candidate expresses ideas clearly, if not always fluently. There are some errors in grammar, punctuation and spelling, but not such as to suggest weakness in these areas.

#### 0 marks

The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage.

- (b) (i)  $\frac{N_s}{N_p} = \frac{V_s}{V_p}$  or  $\frac{2800}{500} = \frac{V_s}{0.23}$  or equivalent [1]  
 $V_s = 1288 \text{ (V)}$  [1] [2]  
 (ii)  $E = \text{rate of change in flux linkage or } = AN(B/t)$  [1]  
 $1290 = 2.20 \times 10^{-4} \times 2800 \times (B/t)$  [1]  
 $(B/t) = 2094 \text{ (T s}^{-1}\text{)}$  [1] [3]

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- 6 (a) (i)  $E = V/d$  or  $= 148/0.08$  [1]  
 $= 1850$  [1] [2]  
 (ii)  $a = F/m$  [1]  
 $a = (2.96 \times 10^{-16}/1.66 \times 10^{-27}) = 1.77 \times 10^{11} \text{ (m s}^{-2}\text{)}$  [1] [2]  
 (b) Allow ecf within this part  
 Time in the B-field  $(= 120 \times 10^{-3}/4.00 \times 10^5)$   
 $= 3.00 \times 10^{-7} \text{ s}$  [1]  
 Vert comp of velocity  $= 1.77 \times 10^{11} \times 3.00 \times 10^{-7}$   
 $= 5.31 \times 10^4 \text{ (m s}^{-1}\text{)}$  [1]  
 Velocity  $= [(5.31 \times 10^4)^2 + (4.00 \times 10^5)^2]^{1/2}$   
 $= 4.04 \times 10^5 \text{ (m s}^{-1}\text{)}$  [1]  
 Angle  $= \tan^{-1} (5.31 \times 10^4/4.00 \times 10^5) = 7.56^\circ$  [1]  
 below horizontal [1] [5]

9

- 7 (a) (i) To prevent energy losses (through collisions) [1]
- (ii) To give protons energy [1]
- (iii)  $Bqv = mv^2/r$  [1]  
 $B = (5 \times 1.67 \times 10^{-27}) \times (0.98 \times 3.00 \times 10^8) /$   
 $(1.60 \times 10^{-19} \times 6 \times 10^3)$  [1]  
 $B = 2.56 \times 10^{-3} \text{ (T)}$  [1] [3]
- (b) (i) Matter composed of anti-particles [1]
- (ii)  $E = mc^2$  [1]  
 $E = (0.125 \times 10^{-3} \times 2) \times (3.00 \times 10^8)^2$  [1]  
 $E = 2.25 \times 10^{13} \text{ (J)}$  [1] [3]  
 $SE \ 1.13 \times 10^3 \rightarrow \frac{2}{3}$

- 8 (a) Composed of a quark and anti-quark [1]

(b) (i)

Particle	Name	Charge/C	Baryon Number	Lepton Number
$n$			+1	0
$p$		$+1.60 \times 10^{-19}$		0
$e$	electron	$-1.60 \times 10^{-19}$	0	
$\bar{\nu}_e$	(electron) anti-neutrino		0	-1

$[\frac{1}{2}]$  each round down [5]

- (ii) Charge, baryon number and lepton number [1]
- (c) UP, UP, DOWN [1]
- (d)  $(d \rightarrow u) + (W^-)$  [1] for each bracket independently [2]

9

10

<b>9 (a)</b> $n = 1.56$ $\sin C = 1/n$ $C = 39.8^\circ$	[1] [1] [1] [3]
<b>(b) (i)</b> $45^\circ$	[1]
<b>(ii)</b> $\omega = \theta/t$ $\omega = 45/0.08 = 562.5^\circ \text{ s}^{-1}$ or $\omega = (\pi/4)/0.08$ Subs $\omega = 9.81 \text{ (rad s}^{-1}\text{)}$ ECF <b>(b)(i)</b>	[1] [1] [1] [3]
<b>(c)</b> Side length = $\sqrt{(\text{pixel area})} =$ $\sqrt{(7.68/12 \times 10^6)} = \sqrt{(6.4 \times 10^{-7} \text{ cm}^2)}$ Length = $8 \mu\text{m}$ Apply $10^n$ penalty once	[1] [1] [1] [3]
<b>(d) (i)</b> $E = hc/\lambda$ $= 1.1 \times 1.6 \times 10^{-19}$ $\lambda = 1.13 \times 10^{-6} \text{ (m)}$	[1] [1] [1] [3]
<b>(ii)</b> (No. photons = $2.5 \times$ no. electrons No. electrons = total charge/electron charge $\frac{3.52 \times 10^{-15}}{1.6 \times 10^{-19}}$ No. electrons = 22 No. photons = 55	[1]  [1] [1] [1] [3]

Total

16

90