Rewarding Learning

ADVANCED
General Certificate of Education
2012

Physics

Assessment Unit A2 2

assessing

Fields and their Applications

[AY221]

FRIDAY 25 MAY, AFTERNOON

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 give 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)**	(Every) mass/body (in the universe) attracts (every) other body/ mass.	[1]		
	Force is directly proportional to the product of their masses	[1]		
	and inversely proportional to the square of their separations.	[1]	[3]	
(b) **(i)**	A satellite which has the same period/angular velocity as the planet/24 h	[1]		
	and always stays at the same height above the equator	[1]	[2]	
		[1]		
(ii)	$m\omega^2 r = Gmm_m/r^2$	[1]		
	$\omega = 2\pi/T = 2\pi/(24.6 \times 3600) = 7.09 \times 10^{-5}$			
	$r^3 = Gm_m/\omega^2 = 6.67 \times 10^{-11} \times 6.42 \times 10^{23}/(7.09 \times 10^{-5})^2 = 8.5 \times 10^{21}$			
	$r = 2.04 \times 10^7$ m ECF ω	[1]		
	Distance above surface $= 2.04 \times 10^4 - 3.39 \times 10^3$ km			
	$= 17.0 \times 10^3$ km ECF r	[1]	[4]	9
2 **(a)** **(i)**	$F = q_1q_2/4\pi\varepsilon_0 r^2 = 3 \times 10^{-9} \times 2 \times 10^{-9} \times 9 \times 10^{-9}/(20 \times 10^{-3})^2$ Eqn + subs	[1]		
	$= 1.35 \times 10^{-4}$ N	[1]		
	Repulsive	[1]	[3]	
(ii)	Eqn, values $E = 9 \times 10^9 \left(\underset{= 2.2 \times 10^4}{\frac{3 \times 10^{-9}}{(35 \times 10^{-3})^2}} + \underset{= 8 \times 10^4}{\frac{2 \times 10^{-9}}{(15 \times 10^{-3})^2}} \right)$	[2]		
	Eqn and/or one correct calculation [1]			
	Ans 1.02×10^5 (NC^{-1})	[1]		
	Direction Right	[1]	[4]	
(b)	Difference: Electric field can produce attraction or repulsion, gravity always attractive/E can be shielded	[1]		
	Similarity: Both obey inverse square laws	[1]	[2]	
(c)	$(E = V/d) = 200/45 \times 10^{-3} = 4.44$ kV m^{-1}	[1]		
	$Q = F/E = 1.1 \times 10^{-3}/4.44 \times 10^3 = 2.48 \times 10^{-7}$ C ECF E	[1]	[2]	11

			AVAILABLE MARKS
3 (a) (i) DC power supply, resistor, capacitor in series	[1]		
Voltmeter correctly positioned	[1]		
Switch or resistance correctly positioned to discharge capacitor	[1]	[3]	
Start timer when charging starts	[1]		
record voltage at (regular) intervals	[1]		
until voltage reaches the supply voltage (i.e. stops rising)	[1]	[3]	
(ii) Correct curve to near horizontal		[1]	
(iii) Correct curve with finite starting points		[1]	
(b) (i) $C_{Total} = 200\mu F$		[1]	
(ii) $Q = CV = 200 \times 10^{-6} \times 15 = 3 \times 10^{-3} C$		[1]	
Voltage across 300 μF capacitor = $Q/C = 3 \times 10^{-3}/3 \times 10^{-4} = 10 V$		[1]	11
4 (a) One tesla is the magnetic flux density which will cause a conductor 1 metre long carrying a current of one amp at right angles to the field to experience a force of one newton. $5 \times [\frac{1}{2}]$, round down		[2]	
(b) (i) 3 Parallel field lines from N to S		[1]	
(ii) Clear arrow vertically upwards showing the force		[1]	
(iii) $B = F/IL$	[1]		
$B = 1.44 \times 10^{-3}/(2.4 \times 4 \times 10^{-2})$	[1]		
$= 0.015 T$	[1]	[3]	7
(10^n error may be applied twice)			

AVAILABLE MARKS

5 **(a)** Diagram showing:
Magnet [1]
Conductor connected to a meter [1]

Describing:
The means of changing flux linkage [1]
How the rate of change in flux linkage is varied [1]

Observation of larger meter reading with greater $\frac{dI}{dt}$ [1]

Faraday's Law:
Induced EMF = rate of change of flux linkage [1] [6]

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. [2]

(b) P = VI or E = VIt [1]
High voltage means low current [1]
Power loss = I^2R (where R = cable resistance) [1] [3] 11

6 **(i)** $\frac{1}{2}mv^2 = eV$ [1]
$2 \times 1.6 \times 10^{-19} \times 800/9.1 \times 10^{-31} = 2.8 \times 10^{14}$ [1]
$v = 1.68 \times 10^{7}\,m\,s^{-1}$ [1] [3]

(ii) Path on diagram is a curve downwards [1]

(iii) $F = Bev = 20 \times 10^{-3} \times 1.6 \times 10^{-19} \times 1.68 \times 10^{7}$
Eqn + subs [1]
$= 5.37 \times 10^{-14}\,N$ allow ecf from **(i)** [1] [2]

(iv) $mv^2/r = Bev$ [1]
$= 9.1 \times 10^{-31} \times (1.68 \times 10^{7})^2/(0.02 \times 1.6 \times 10^{-19})$ [1]
= 4.8 mm allow ecf from **(i)** or **(iii)** [1] [3] 9

AVAILABLE MARKS

7 (a)

	Linac	Cyclotron	Synchrotron
Path of charged particles	Straight line	Circular, spiralling (out)	
Accelerating field frequency		Constant (frequency)	Increasing/ variable
Deflection field type	None		Magnetic, increasing B/ variable
Maximum energy*	(30 GeV)		1000 GeV 1TeV – 3.5 TeV

[$\frac{1}{2}$] each, to a maximum of [4], round down [4]

(b) (i) $2hf = 2mc^2$ [1]
hence
$f = 9.1 \times 10^{-31} \times 9 \times 10^{16} / 6.63 \times 10^{-34} = 1.24 \times 10^{20}$ Hz [1]
$\lambda = c/f = 2.42 \times 10^{-12}$ m [1]
S.E. 1.21 × 10–12 m [2]/[3] [3]

(ii) photons emitted in opposite directions [1] 8

8 (i) Gravitational graviton
Electromagnetism photons
Strong interaction gluons
Weak interaction W^+, W^-, Z^0 (intermediate gauge bosons)
W π Z

[$\frac{1}{2}$] each, round down [4]

(ii) An elementary particle is one with no (apparent) internal structure [1]

(iii) Fundamental v composite [1]
No structure v quark structure [1]
No strong force v strong force [1] [3] 8
Allow lepton/larger number responses

			AVAILABLE MARKS
9 **(a)** **(i)** $N_s/N_p = 12/230$	Eqn, subs [1]		
$= 0.052$	[1]	[2]	
(ii) $R = \rho L/A$			
$= 1.7 \times 10^{-8} \times 6.5 \times 2/(27 \times \pi \times (0.05 \times 10^{-3})^2)$ [1]	Eqn, subs [2]		
$= 1.04\ \Omega$	[1]	[3]	
{Uses 6.5 and not 2 × 6.5 or diameter rather than radius [–1] once only. Uses one strand rather than correct 27 strands for area [–1]}			
(iii) Primary current $= 0.052 \times 740$ ecf **(i)**	[1]		
$= 38.5$ mA	[1]	[2]	
(iv) Energy loss $= I^2Rt$	[1]		
$= 0.74^2 \times 1.04 \times 8 \times 3600$	Eqn subs [1]		
$= 16.4$ kJ	[1]	[3]	
(b) **(i)** blue emitting diodes or 470 nm		[1]	
(ii) **(1)** $f = c/\lambda = 6.38 \times 10^{14}$ Hz	[1]		
(2) $n = \text{power}/hf = 12 \times 10^{-3}/(6.38 \times 10^{14} \times 6.63 \times 10^{-34})$ Eqn, subs	[1]		
$= 2.84 \times 10^{16}\ (s^{-1})$ ecf [1]	[1]	[3]	
(iii) Voltage drop needed across $R = 5.7 - 3.6 = 2.1$ V	[1]		
Hence $R = 2.1/30 \times 10^{-3} = 70\ \Omega$	[1]	[2]	
Alternative methods acceptable			16
		Total	**90**