cea

Rewarding Learning

ADVANCED
General Certificate of Education
2015

Physics

Assessment Unit A2 2

assessing

Fields and their Applications

[AY221]

THURSDAY 4 JUNE, 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 given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation. However, answers to later stages 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.

1 **(a)** $GM/r^2 = \dfrac{6.67 \times 10^{-11} \times 6.42 \times 10^{23}}{(3.39 \times 10^6)^2}$ Equation, subs [2]

          $= 3.73\,Nkg^{-1}$ [1]   [3]

   (b) **(i)** $GmM_s/r^2 = m\omega^2 r = m \times 4\pi^2\, r/t^2$ [1]

         $t^2\, GM_s = 4\pi^2\, r^3$ (allow π or π^2)   [1]

         (Hence t^2 proportional to r^3)   [2]

      (ii) t^2/r^3 for Phobos $= t^2/r^3$ for Deimos   or $r^3 = \dfrac{GMt^2}{4\pi^2}$ [1]

                                                    Subs [1]

         Radius of Deimos $= 2.34 \times 10^7\,m$ [1]   [3]

     (iii) Force $= 6.67 \times 10^{-11} \times 1.07 \times 10^{16} \times 6.42 \times 10^{23}/(9.38 \times 10^6)^2$

                                       Eqn and subs [1]

         Force $= 5.21 \times 10^{15}\,N$ [1]   [2]   10

2 **(i)** 8.15×10^4 ($N\,C^{-1}$ to the left)   [1]
     and 14.3×10^4 ($N\,C^{-1}$ to the right)   [1]

     Resultant $= 6.1 \times 10^4\,N\,C^{-1}$ [1]
     to the right (ecf* E values)   [1]   [4]
     S.E. 1.5×10^4 + to the right [3]/[4]

   (ii) Force $= 8.99 \times 10^9 \times 4 \times 10^{-9} \times 7 \times 10^{-9}/(42 \times 10^{-3})^2$

                                       Eqn and subs [1]

     Force $= 1.43 \times 10^{-4}\,N$ [1]   [2]

   (iii) $T \sin 30° = 1.43 \times 10^{-4}$ ecf   [1]
     $T = 2.86 \times 10^{-4}$ (N)   [1]   [2]

   (iv) Weight $= T \cos 30°$ or   Pythagoras theorem   [1]
     Weight $= 2.48 \times 10^{-4}\,N$ ecf   [1]   [2]   10

AVAILABLE MARKS

3 **(a)** Recall Q = CV, Q = It   ([$\frac{1}{2}$] each round down)   [1]

τ = R × C = (V/I) × C = (V/Q × time) × Q/V = time   [1]   [2]

(b) **(i)**
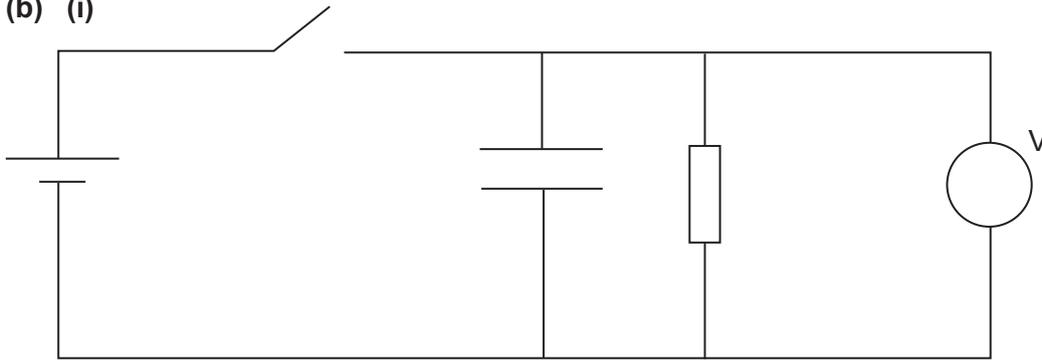
Workable circuit (ammeter use ok)   [1]

Switch   [1]   [2]

[–1] incorrect symbol or symbols

(ii) Charge the capacitor by closing switch.   [1]

Open switch and allow capacitor to discharge, recording

voltage and time.   [1]   [2]

(iii) Plot voltage and time,   [1]

reading the time when the voltage falls to 37% of its initial value.

This time is the time constant.

(or equivalent)   [1]   [2]

Accept correct responses for a charging circuit and the use

of ammeter and current

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. Arguments

may sometimes stray from the point. There are some errors in grammar,

punctuation and spelling, but not such as to suggest a 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]

(c) **(i)** Q = C × V = 300 × 10^{-6} × 600   [1]

Charge = 1.8 × 10^{-1} C   [1]   [2]

(ii) Total capacitance = 800 μF   [1]

V = Q/C = 1.8 × 10^{-1}/800 × 10^{-6} [1]

Potential difference = 225 V   ecf   [1]   [3]

S.E. 960 V → [1]/[3]

15

| | | | | | | AVAILABLE MARKS |

4 (a) (i) $E = \frac{\delta N\Phi}{\delta t}$ or equivalent eqn [1]

dt = (50 Hz → B varies from max to min in 0.005 s) [1]

$E = \frac{(1.6\times10^{-3})(0.0048)(200)}{0.005} = 0.31(V)$ ecf* dt [1] [3]

accept use of E0 =BAnW ⇒ 0.48 V
S.E. 0.07 → [2]/[3]

(ii) Neighbouring poles are the same/opposing fields [1]
Due to Lenz's law [1] [2]

(iii) The induced emf will be larger [1]
More magnetic flux linkage between the coils [1] [2]

(b) Laminated [1]
Reduces eddy currents [1] [2] **9**

5 (i) v² = 2eV/m
or eV = $\frac{1}{2}$ mv² eqn [1]
v² = 2 × 1.6 × 10⁻¹⁹ × 200/9.1 × 10⁻³¹ subs [1]
v = 8.39 × 10⁶ ms⁻¹ QED [2]

(ii) Transit time = distance/velocity
= 0.04/8.4 × 10⁶ [1]
= 4.8 ns [1] [2]

(iii) Parallel field lines/arrows from the top to bottom plate
(ignore edge effects) [1]
Curvature of beam upwards towards top plate [1] [2]

(iv) 1. Force on electrons
= Vq/d [1]
= 2.67 × 10⁻¹⁶ (N) [1] [2]

2. Acceleration
= F/m = 2.67 × 10⁻¹⁶/9.1 × 10⁻³¹ = 2.93 × 10¹⁴ ms⁻² ecf [1]
Initial vertical component of velocity = 0 [1]
Deflection = $\frac{1}{2}$ at² = 3.33 mm ecf* [1] [3]

(v) Perpendicular to and [1]
into the page [1] [2] **13**

6 **(a)** **(i)** To avoid collisions [1]

(ii) They are not in an (accelerating) electric field [1]

(iii) $Bqv = mv^2/r$ [1]

$r = mv/Bq = 1.67 \times 10^{-27} \times 2 \times 10^5/0.7 \times 1.6 \times 10^{-19}$ Subs [1]

Radius $= 2.98 \times 10^{-3}$ m [1] [5]

(b) Work done $= qV$ [1]

$= 500 \times 1.6 \times 10^{-19} \times 120$ [1]

Energy acquired $= 9.6 \times 10^{-15}$ J [1] [3] 8

7 **(a)** **(i)** No internal structure [1]

(ii) e.g. an electron, electron neutrino, muon [1]

(b) **(i)** e.g.

Particle	Structure	Quark charges	Particle charge
proton	u u d	+2/3(e) +2/3(e) −1/3(e)	+e or +1
neutron	u d d	+2/3(e) −1/3(e) −1/3(e)	0

Accept relative charge
$8 \times [\frac{1}{2}]$ round down [4]

(ii) All three [1]

(c) **(i)** $udd \rightarrow uud + e^- + \bar{\nu}$ [1]

(ii) Weak (nuclear) force [1] 9

8 **(a)** **(i)** Mass per second = volume per second × density = $Av × \rho$ [1]

(ii) $KE = \frac{1}{2}mv^2 = \frac{1}{2}Av\rho × v^2 = \frac{1}{2}A\rho v^3$ [1]

(iii) Power depends on v^3 hence a 2% increase in v
equates with $(1.02)^3 = 1.06 = 6\%$ [1]

(b) **(i)** 1. $\lambda = c/f = 3 × 10^8/2.29 × 10^{14}$ Hz = 1310 nm = $1.31 × 10^{-6}$ m [1]

2. Infrared [1] [2]

(ii) Signal transit time = $20\,000/2.4 × 10^8 = 8.3 × 10^{-5}$ s [1]

(c) **(i)** An aluminium cable needs strengthened/steel strong [1]
it would sag/stretch [1] [2]

(ii) $R = \dfrac{\rho l}{A}$ [1]

Resistance of 20 km of aluminium = 0.0142 Ω [1]

Resistance of 20 km of one strand of steel = 1.06 Ω [1]

Resistance of 20 km of 8 strands of steel = 0.133 Ω [1]

Resistors in parallel calculation [1]

Resistance of 20 km of combination = 0.0128 Ω   (ecf)* [1] [6]

(iii) Power loss = $I^2R = (2000)^2 × 0.0128$ [1]
= 51 kW   (ecf) [1] [2]   16

Total   **90**