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.

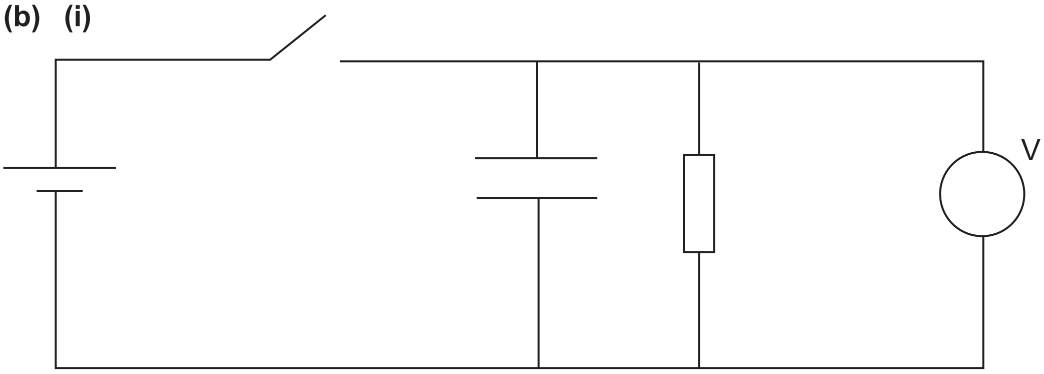
**Do not reward wrong physics.** No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation. However, answers to later stages that are consistent with an earlier incorrect numerical answer, and are based on physically correct equation, 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 $550 \times 10^{-6}$ m) count only as arithmetical slips and lose the answer mark.

| | | | | AVAILABLE MARKS |
|---|---|---|---|---|
| **1** **(a)** $GM/r^2 = \dfrac{6.67\times10^{-11}\times6.42\times10^{23}}{(3.39\times10^{6})^2}$ | Equation, subs [2] | | | |
| $= 3.73\,\text{N kg}^{-1}$ | [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 $\pi$ *or* $\pi^2$) | [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)** $8.15 \times 10^4$ (N $C^{-1}$ to the left) | [1] | | | |
| and $14.3 \times 10^4$ (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. $1.5 \times 10^4$ + 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 |

| | | | | | |
|---|---|---|---|---|---|
| **3** | **(a)** | Recall Q = CV, Q = It ([$\frac{1}{2}$] each round down) | [1] | | |
| | | $\tau$ = 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 = $300 \times 10^{-6} \times 600$ [1]
Charge = $1.8 \times 10^{-1}$ C [1] [2]

**(ii)** Total capacitance = 800 μF [1]
V = Q/C = $1.8 \times 10^{-1}/800 \times 10^{-6}$ [1]
Potential difference = 225 V ecf [1] [3]
S.E. 960 V → [1]/[3]

AVAILABLE MARKS: 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] | | |
| | | | $E = \frac{(1.6 \times 10^{-3})(0.0048)(200)}{0.005} = 0.31\,(V)$ ecf* *dt* | [1] | [3] | |
| | | | accept use of E0 =BAnW ⇒ 0.48 V<br>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) | | $v^2 = 2eV/m$ | | | |
| | | | or $eV = \frac{1}{2}mv^2$ | eqn [1] | | |
| | | | $v^2 = 2 \times 1.6 \times 10^{-19} \times 200/9.1 \times 10^{-31}$ | subs [1] | | |
| | | | $v = 8.39 \times 10^6\,\mathrm{m\,s^{-1}}$ QED | | [2] | |
| | (ii) | | Transit time = distance/velocity | | | |
| | | | $= 0.04/8.4 \times 10^6$ | [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] | | |
| | | | $= 2.67 \times 10^{-16}$ (N) | [1] | [2] | |
| | | 2. | Acceleration | | | |
| | | | $= F/m = 2.67 \times 10^{-16}/9.1 \times 10^{-31} = 2.93 \times 10^{14}\,\mathrm{m\,s^{-2}}$ ecf | [1] | | |
| | | | Initial vertical component of velocity = 0 | [1] | | |
| | | | Deflection = $\frac{1}{2}at^2$ = 3.33 mm ecf* | [1] | [3] | |
| | (v) | | Perpendicular to and [1]<br>into the page [1] | | [2] | 13 |

| | | | | | | AVAILABLE MARKS |
|---|---|---|---|---|---|---|
| **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 → uud + $\mathbf{e}^-$ + $\overline{\nu}$ [1]

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

| | | | | | AVAILABLE MARKS |
|---|---|---|---|---|---|
| **8** | **(a)** **(i)** | Mass per second = volume per second × density = Av × ρ | | [1] | |
| | **(ii)** | KE = $\frac{1}{2}mv^2 = \frac{1}{2}Av\rho \times v^2 = \frac{1}{2}A\rho v^3$ | | [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. $\lambda = c/f = 3 \times 10^8 / 2.29 \times 10^{14}$ Hz = 1310 nm = $1.31 \times 10^{-6}$ m | [1] | | |
| | | 2. Infrared | [1] | [2] | |
| | **(ii)** | Signal transit time = $20\,000/2.4 \times 10^8 = 8.3 \times 10^{-5}$ s | | [1] | |
| | **(c)** **(i)** | An aluminium cable needs strengthened/steel strong | [1] | | |
| | | it would sag/stretch | [1] | [2] | |
| | **(ii)** | $R = \frac{\rho l}{A}$ | [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 = $I^2R = (2000)^2 \times 0.0128$ | [1] | | |
| | | = 51 kW (ecf) | [1] | [2] | 16 |
| | | | | **Total** | **90** |