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# MARKSCHEME

## November 2010

## PHYSICS

## Standard Level

## Paper 2

13 pages

**1.** Follow the markscheme provided, award only whole marks and mark only in **RED**.

**2.** Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

**3.** Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation to explain your decision. You are encouraged to write comments where it helps clarity, especially for re-marking. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

**4.** Personal codes/notations are unacceptable.

**5.** Make sure that the question you are about to mark is highlighted in the right hand window.

**6.** Where an answer to a part question is worth no marks, put a zero in the right-hand window.

**7.** If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. Check **every** page carefully.

**8.** A mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

# Subject Details: Physics SL Paper 2 Markscheme

**Mark Allocation**

Candidates are required to answer **ALL** questions in Section A **[25 marks]** and **ONE** question in Section B **[25 marks]**. Maximum total=**[50 marks]**.

**1.** A markscheme often has more marking points than the total allows. This is intentional. Do **not** award more than the maximum marks allowed for part of a question.

**2.** Each marking point has a separate line and the end is signified by means of a semicolon (;).

**3.** An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

**4.** Words in brackets ( ) in the markscheme are not necessary to gain the mark.

**5.** Words that are <u>underlined</u> are essential for the mark.

**6.** The order of marking points does not have to be as in the markscheme, unless stated otherwise.

**7.** If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing ***OWTTE*** (or words to that effect).

**8.** Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

**9.** Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. Indicate this with **ECF** (error carried forward).

**10.** Only consider units at the end of a calculation. Unit errors can only be penalized once in the paper. Place ticks for all correct marking points and use the "**U**" stamp from the annotations at the appropriate place. The unit error (**–1**) mark then shows in the "whole paper" section of the right hand box and the mark is automatically deducted from the whole paper.

**11.** Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

*e.g.* if the answer is 1.63:

| | |
|---|---|
| 2 | *reject* |
| 1.6 | accept |
| 1.63 | accept |
| 1.631 | accept |
| 1.6314 | *reject* |

Place ticks for all correct marking points and use the "**SD**" stamp at the appropriate place. The significant digit (**–1**) mark then shows in the "whole paper" section of the right hand box and the mark is automatically deducted from the whole paper.

## SECTION A

**A1.** (a) (i) percentage uncertainty in distance $=\left(\frac{0.01}{0.75}=\right)1.3\%$;

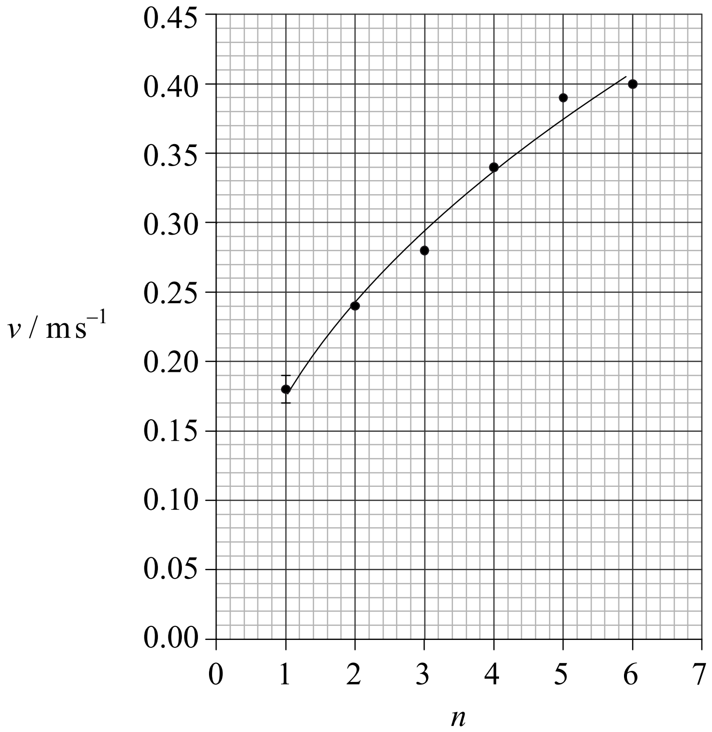
percentage uncertainty in $v=(5+1.3=)6.3\%$;

absolute uncertainty in $n=6$ point is $(0.40\times0.063=)0.025\,\text{m s}^{-1}$; ***[3]***

(ii) overall length of error bar drawn correct to within half a small square; ***[1]***

*Consistent with (a)(i).*

(b) any reasonable smooth curve/straight-line passing through error bars ***[1]***




(c) tests for $\frac{v}{n}$ ***or*** $\frac{n}{v}$;

$\frac{v}{n}=0.12$ for $n=2$ and $\frac{v}{n}=0.085$ for $n=4$; *(both needed)*

hypothesis incorrect because two values should be equal. ***[3]***

(d) $\left(\text{if } v\propto\sqrt{n}\right)\ v^2\propto n$;

graph of $v^2$ against $n$ is a straight-line;

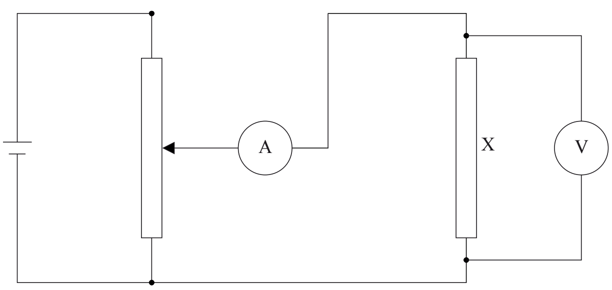
that goes through the origin; ***[3]***

**A2.** (a) $11\,\text{m}\,\text{s}^{-2}$; ***[1]***

(b) $\Delta v = 236$;
$a = \left(\dfrac{236}{8} = \right) 29.5\left(\text{m}\,\text{s}^{-2}\right)$;
$\left(F = 1.1\times10^{4}\times29.5\right) = 3.2\times10^{5}\,\text{N}$; ***[3]***
*Award **[2 max]** for omission of initial speed (answer is 390 kN).*

(c) phase 1 distance 88 m / phase 2 distance 1296 m;
total 1400 m; ***[2]***
*Watch for significant figure penalty in this question (1384 m).*
*Award **[1 max]** for $\frac{1}{2}at^2$ substituted correctly for first phase, if no distances evaluated and answer incorrect.*
*Award **[1 max]** for correct addition of incorrect phase 1 and/or 2 distance(s).*

**A3.** (a) voltmeter in parallel across X;
ammeter in series with X;
correct circuit; *(allow ecf from 1st and 2nd marking points)* ***[3]***
*Accept voltmeter connections that include ammeter (in series with X)*
*Condone re-drawing of resistor X closer to variable resistor.*




(b) $I = 2.4\,\text{A}$ at $2.0\,\text{V}$;
$\dfrac{2}{2.4}$;
$= 0.83\,\Omega$ ***[2]***
*Award **[1 max]** for use of gradient of graph from (2,2.4) to origin.*

(c) total p.d. across $1\,\Omega$ resistor $= 1.3\,(\text{V})$;
p.d. across $\text{X} = 0.7\,(\text{V})$;
reading from graph $I = 1.3\,\text{A}$ at $0.7\,\text{V}$ / evidence that the graph has been read; ***[3]***
*Award **[1 max]** if value of calculated p.d. is incorrect but there is clear graphical evidence of derivation of current (typically marks on graph).*

***or***

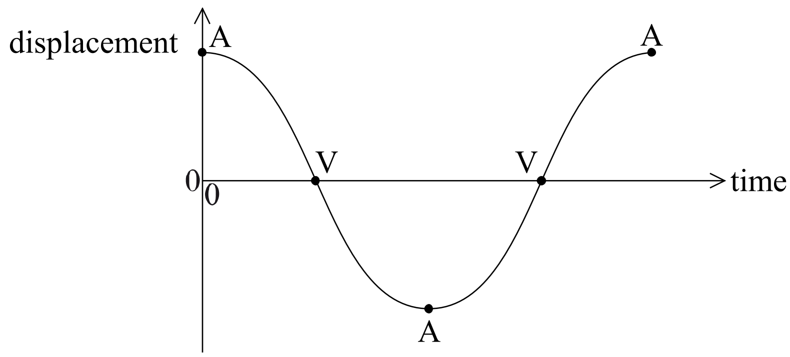
total p.d. across X + resistor $= 2.0\,(\text{V})$;
this occurs when $V_{\text{X}} = 0.7\,(\text{V})$ and $V_{1.0} = 1.3\,(\text{V})$;
at $I = 1.3\,\text{A}$;

## SECTION B

**B1. Part 1** Simple pendulum

(a) (i) one A correctly shown; ***[1]***

(ii) one V correctly shown; ***[1]***

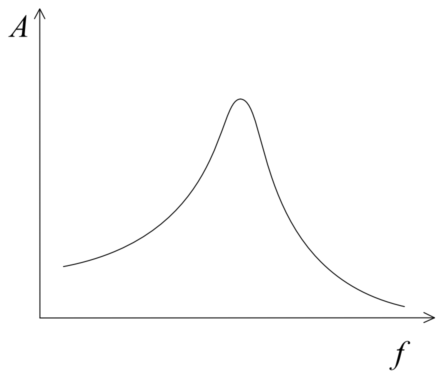



(b) pendulum bob accelerates towards centre of circular path / *OWTTE*;
therefore force upwards;
that <u>adds</u> to tension produced by the weight; ***[3]***

(c) (i) evidence shown of equating kinetic energy and gravitational potential energy;
$v = \sqrt{(2 \times 9.8 \times 0.025)}$;
$= 0.70\,\mathrm{m\,s^{-1}}$ ***[2]***
*Allow* $g = 10\,m\,s^{-2}$ *answer 0.71* $m\,s^{-2}$.

(ii) centripetal acceleration $\left(=\frac{v^2}{r}\right)\left[=\frac{0.7^2}{0.8}\right] = 0.61\left(\mathrm{m\,s^{-2}}\right)$;
net acceleration $= (9.81 + 0.61 =)\,10.4\left(\mathrm{m\,s^{-2}}\right)$ ***or*** $T - mg = m \times 0.61$;
tension $= (ma =)\,0.59\,\mathrm{N}$; ***[3]***
*Allow* $g = 10\,m\,s^{-2}$ *answer 0.60N.*

(d) (i)




one maximum shown <u>and</u> curve broadly similar to example above;
amplitude falls on each side as shown; ***[2]***

(ii) resonance is where driving frequency equals/close to natural frequency;
the frequency at the maximum amplitude of the graph; ***[2]***

(e) lower amplitude everywhere on graph;
with a much broader resonance peak;
maximum moves to left on graph; ***[2 max]***
*Award* ***[2]*** *for a sketch graph.*

**Part 2** Rutherford model of the atom

(a) most of the atom is empty space;
most of the mass/(protonic) charge of the atom is concentrated in the nucleus/ nucleus is dense;
nucleus is positively charged;
(most) alphas not close enough to nuclei to be deflected;
(very few) alphas (are) close enough to nuclei to be deflected;
*These points can be awarded to a labelled diagram.* ***[5]***

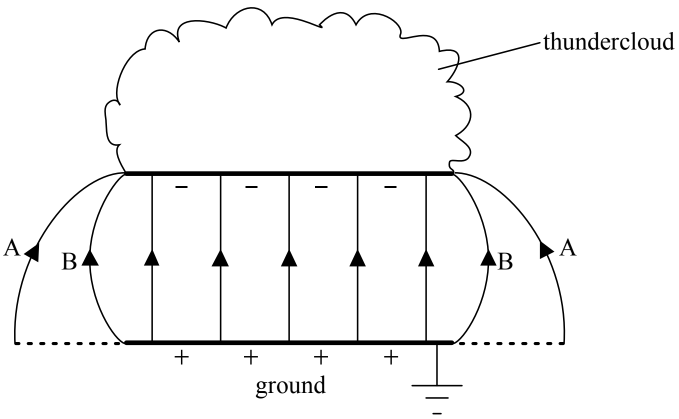
(b) (i) mention of Coulomb repulsion between protons;
mention of strong (nuclear) force (between nucleons);
overall balance must be correct (and more neutrons needed for this); ***[3]***
*Award* ***[0]*** *for a statement that neutron is negative.*

(ii) anti neutrino / $\overline{v}$ ; ***[1]***

**B2. Part 1** Lightning discharge

(a) force acting per unit charge;
on positive test / point charge; ***[2]***

(b)




lines connecting plate and ground equally spaced in the central region of thundercloud
and touching both plates; *(judge by eye)*
edge effects shown; *(accept either edge effect A or B shown on diagram)*
field direction correct; ***[3]***

(c) (i) $\sigma = \left(\frac{35}{1.2\times10^{7}} =\right) 2.917\times10^{-6}\,(\mathrm{C\,m^{-2}})$;

$E = \frac{2.917\times10^{-6}}{8.85\times10^{-12}}$;

$=3.3\times10^{5}\,\mathrm{N\,C^{-1}}$ ***or*** $\mathrm{V\,m^{-1}}$; ***[3]***

(ii) edge of thundercloud parallel to ground;
thundercloud and ground effectively of infinite length;
permittivity of air same as vacuum; ***[2 max]***

(iii) $t = \frac{Q}{I}$;

$t = \frac{35}{1800}$;

$= 20\,\mathrm{ms}$; ***[3]***

(iii) use of energy $=$ p.d. $\times$ charge;
average p.d. $= 1.25\times10^{8}$ (V);
energy released $= 1.25\times10^{8}\times35$;
$= 4.4\times10^{9}$ J; ***[4]***
*Award* ***[3 max]*** *for 8.8 GJ if average p.d. point omitted.*

*Allow ecf from (c)(ii).*

**Part 2** Fuel for heating

(a) energy (released) per unit mass; *[1]*
*Accept per unit volume or per kg or per* $m^3$.
*Do not accept per unit density.*

(b) (i) volume of fuel used per second $= \dfrac{\text{rate}}{\text{density}} \left(= 1.63 \times 10^{-7}\ (\text{m}^3)\right)$;

energy per second $= 2.7 \times 10^{10} \times 1.63 \times 10^{-7}$;
$= (4.3875 =) 4.4\,\text{kW}$; *[3]*

(ii) power required $= \left(2.9 \times 10^5 \times 0.13 \times 10^{-3} =\right) 38\,\text{W}$;
small fraction/less than 1% of overall power output / *OWTTE*; *[2]*

(c) sensible comment comparing molecular structure;
*e.g. liquid molecular structure (more) ordered than that of a gas.*
*in gas molecules far apart/about 10 molecular spacings apart / in liquid molecules close/touching.*

sensible comment comparing motion of molecules; *[2]*
*e.g. in liquid: molecules interchange places with neighbouring molecules / no long distance motion.*
*in gases: no long-range order / long distance motion.*

**B3. Part 1** Production of energy in nuclear fission

(a) (i) 3; ***[1]***

(ii) $\Delta m = 234.99333 - 91.90645 - 140.88354 - [2 \times 1.00867]$;
$= 0.186\,(\text{u})$;
energy released $= 0.186 \times 931 = 173\,(\text{MeV})$;
$173 \times 10^{6} \times 1.6 \times 10^{-19}$;
$(= 2.768) \approx 2.8 \times 10^{-11}$ (J) ***[4]***

***or***

$\Delta m = 234.99333 - 91.90645 - 140.88354 - [2 \times 1.00867]$;
$= 0.186\,(\text{u})$;
mass converted $= 0.186 \times 1.66 \times 10^{-27} \left(= 3.09 \times 10^{-28}\right)$;
(use of $E = mc^2$) energy $= 3.09 \times 10^{-28} \times 9 \times 10^{-16}$;
$(= 2.77) \approx 2.8 \times 10^{-11}$ (J)
*Award **[2 max]** if mass difference is incorrect.*

*Award **[3 max]** if the candidate uses a value for x inconsistent with (a)(i).*

(iii) greater/higher energy; ***[1]***

(b) reduces neutron speed to (thermal) lower speeds;
so that chance of initiating fission is higher; ***[2]***
*Accept "fast neutrons cannot cause fission" for 2nd marking point.*

(c) 40 % efficient so 40 (MW) required;
$\dfrac{40 \times 10^{6}}{2.8 \times 10^{-11}} = 1.43 \times 10^{18}$ per second;
number of fissions per day $= 1.23 \times 10^{23}$;
$\left(= \dfrac{1.23 \times 10^{23} \times 235}{6 \times 10^{23}}\right) = 48$ g per day; ***[4]***

**Part 2** Collisions

(a) the total momentum of a system is constant;
provided external force does not act; ***[2]***

***or***

the momentum of an isolated/closed system;
is constant;
*Award **[1]** for momentum before collision equals collision afterwards.*

(b) (i) initial momentum $= 2.0\times10^{-3}\times140$;
final speed $= \dfrac{2.0\times10^{-3}\times140}{5.6\times10^{-2}+2.0\times10^{-3}}$;
$= 4.8\,\text{m s}^{-1}$ ***[2]***
*Watch for incorrect mass values in equation.*

(ii) initial kinetic energy of pellet + clay block $= \frac{1}{2}mv^2$;
$0.5\times0.058\times4.8^2$ $(=0.67\,\text{J})$;
force $= \dfrac{\text{work done}}{\text{distance travelled}}$;
$=0.24\,\text{N}$; ***[4]***

***or***

use of appropriate kinematic equation with consistent sign usage *e.g.* $a=\dfrac{u^2-v^2}{2s}$;

$a=\dfrac{4.8^2}{2\times2.8}$;
$F=\dfrac{0.058\times4.8^2}{2\times2.8}$;
$=0.24\,\text{N}$;

(c) <u>kinetic</u> energy of pellet is transferred to <u>kinetic</u> energy of clay block;
and internal energy of pellet and clay block;
clay block loses kinetic energy as thermal energy/heat; ***[3]***

(d) $v=\sqrt{2gs}$;
$= 4.1\,\text{m s}^{-1}$; ***[2]***
*Allow* $g=10\,\text{m s}^{-2}$ *answer* $4.1\,\text{m s}^{-2}$