MARKSCHEME

November 2010

PHYSICS

Higher Level

Paper 2

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 moderation and re-marking. It should be remembered that the script may be returned to the candidate.

4. Unexplained symbols or personal codes/notations are unacceptable.

5. Record marks in the right-hand margin against each mark allocation shown in square brackets *e.g.* ***[2]***. The total mark for a question must equal the number of ticks for the question.

6. Do **not** circle sub-totals. **Circle the total mark** for the question in the right-hand margin **at the end of the question.**

7. Where an answer to a part question is worth no marks, put a zero in the right-hand margin next to the square bracket.

8. Where work is submitted on additional sheets the marks awarded should be shown as ticks and a note made to show that these marks have been transferred to the appropriate square bracket in the body of the script.

9. Section A: Add together the total for each question and write it in the Examiner column on the cover sheet.
Section B: Insert the total for each question in the Examiner column on the cover sheet.
Total: Add up the marks awarded and enter this in the box marked TOTAL in the Examiner column on the cover sheet.

10. After entering the marks on the front cover check your addition to ensure that you have not made an error. Check also that you have transferred the marks correctly to the cover sheet. **All scripts are checked and a note of all clerical errors will be given in feedback to examiners.**

11. If an answer extends over more than one page and no marks have been awarded on a section draw a diagonal line through that section to indicate that it has been marked.

12. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers and use the marks of those answers that have the highest mark, **even if the candidate has indicated the question(s) to be marked on the cover sheet**.

13. A mark should not be awarded where there is contradiction within an answer. Make a comment to this effect in the left-hand margin.

Subject Details: Physics HL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[45 marks]** and **TWO** questions in Section B **[2 % 25 marks]**. Maximum total = **[95 marks]**.

1. A markscheme often has more marking points than the total allows. This is intentional. Do **no**t 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 underlined 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. Unless directed otherwise in the markscheme, unit errors should only be penalized once in the paper. Indicate this by writing **–1(U)** at the first point it occurs and **U** on the cover sheet.

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*

    Indicate the mark deduction by writing **–1(SD)** at the first point it occurs and **SD** on the cover sheet.

SECTION A

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

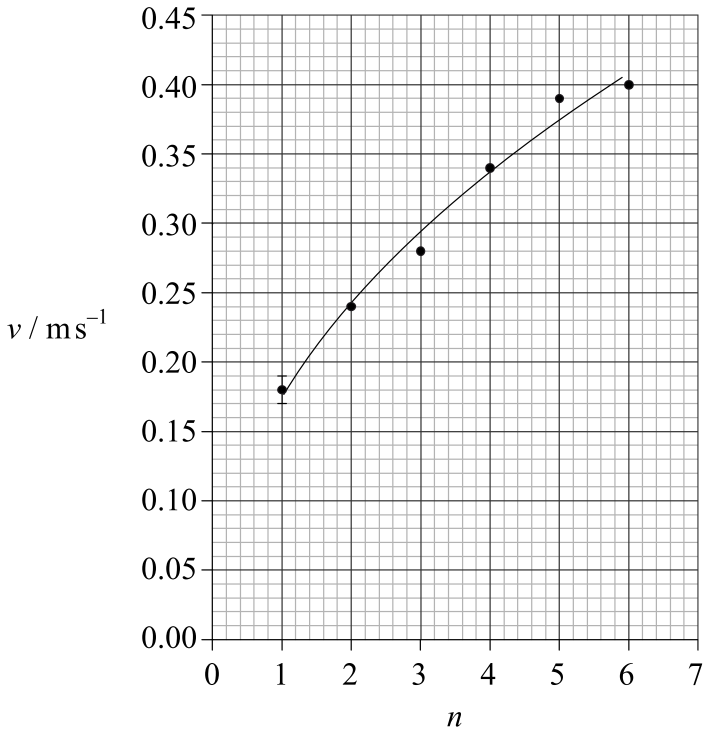
percentage uncertainty in $v=(5+1.3=)6.3\%$;

absolute uncertainty in $n=6$ point is $(0.40\times 0.063=)0.025\,\mathrm{m\,s^{-1}}$; ***[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) $\lg v = 0.5\lg n + \text{constant}$;

large triangle greater than half line used / uses two sets of points at least 0.4 (in $\lg n$) apart;

read-off and substitution correct;

determines gradient $=0.50\pm 0.05$; ***[4]***

A2. (a) energy (released) per unit mass; ***[1]***
Accept per unit volume or per kg or per m^3.
Do not accept per unit density.

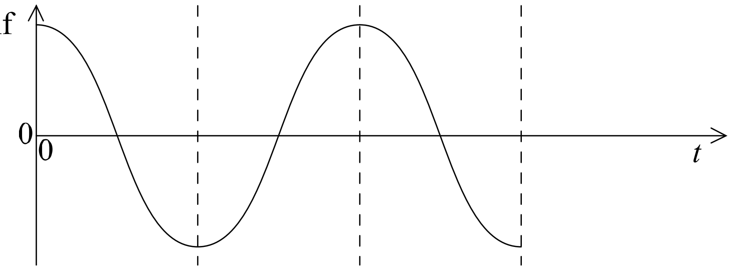
(b) (i) volume of fuel used per second $= \dfrac{\text{rate}}{\text{density}} \left(= 1.63 \times 10^{-7}\ (\text{m}^3)\right)$;
energy per second $= 2.7 \times 10^{10} \times 1.63 \times 10^{-7}$;
$= (4.3875 =)\, 4.4\,\text{kW}$; ***[3]***

(ii) temperature change $= 20$ (K);
mass of air $= \dfrac{4400}{20 \times 990}$;
$= 0.22$ kg; ***[3]***

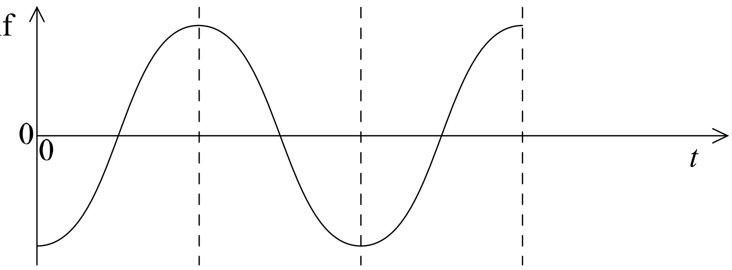
A3. (a) mention of pits; *(allow bumps/flats/islands etc.)*
laser/coherent light used;
light is monochromatic;
pits are $\frac{1}{4}$ wavelength deep;
These points can be awarded to a labelled diagram.
mention of constructive/destructive interference; ***[4 max]***

(b) more layers of pits on the Blu-ray disk possible (because pits now shallower);
the wavelength is smaller therefore higher resolution;
track separation can be smaller;
pit spacing can be smaller;
Allow "track smaller" ***[1]*** *as substitute for both marking points.*
more information can be stored; ***[4 max]***

A4. (a) induced emf is (directly) proportional/equal to rate of change/cutting of flux (linkage);
current produces a (time changing) magnetic field;
field changes with time;
which produces a time changing flux in the coil; ***[3 max]***

(b) 

or



same frequency as current graph;
$\pm 90^\circ$ phase shift; ***[2]***

(c) if the coil position/orientation relative to the cables is the same in all measurements;
if the coil distance from the cables is the same in all measurements;
the voltage measured across the coil is proportional to current in the cable; ***[3]***

A5. (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;
$\left.\right\}$ *These points can be awarded to a labelled diagram.* ***[5]***

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

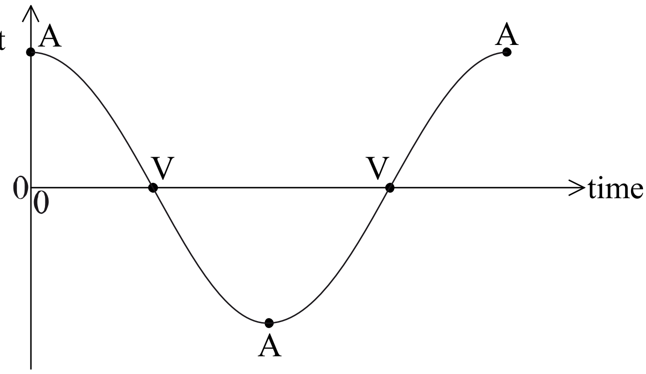
(ii) electron/beta (condone lack of sign);
anti neutrino / $\overline{v}$; ***[2]***

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 adds 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 $g = 10\,\mathrm{m\,s^{-2}}$ *answer* $0.71\,\mathrm{m\,s^{-2}}$.

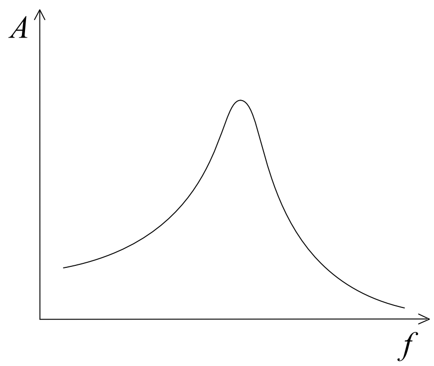
(ii) centripetal acceleration $\left(= \frac{v^2}{r}\right)\left[= \frac{0.7^2}{0.8}\right] = 0.61\left(\mathrm{m\,s^{-2}}\right)$;

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 $g = 10\,\mathrm{m\,s^{-2}}$ *answer* $0.60\,\mathrm{N}$.

(d) (i)



one maximum shown and 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 de Broglie hypothesis

(a) all particles behave as waves;
wavelength given by $\frac{h}{p}$ symbols must be defined; ***[2]***

(b) KE of electron $= 1.4 \times 10^{-17}$ J;
combine $\lambda = \frac{h}{p}$ and $E_{\text{k}} = \frac{p^2}{2m}$ to get $\lambda^2 = \frac{h^2}{2mE_{\text{k}}}$;
$\lambda^2 = \frac{\left[6.6 \times 10^{-34}\right]^2}{2 \times 9.1 \times 10^{-31} \times 1.4 \times 10^{-17}}$;
$\lambda = 1.3 \times 10^{-10}$ m ***[3]***

or

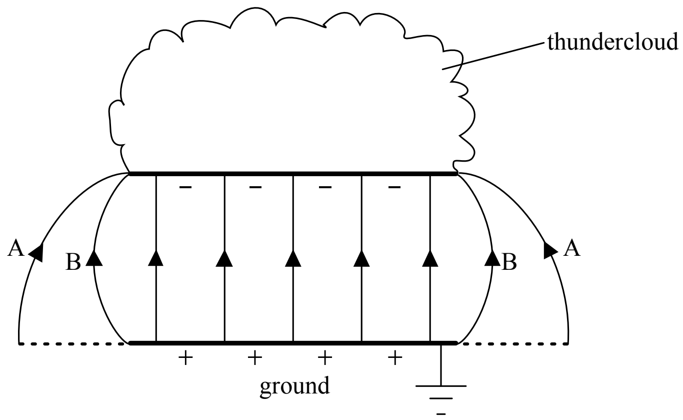
$v = \sqrt{\frac{2eV}{m}}$;
$p = \sqrt{2meV}$;
$\lambda = \left(\frac{h}{\sqrt{2meV}} = \right)\frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 85}}$;
$\lambda = 1.3 \times 10^{-10}$ m

(c) minimum read-off at 0.15 rad; *(allow answers in the range of 0.14 rad to 0.16 rad)*
$\lambda = \frac{b\theta_{\min}}{1.22}$;
$= 1.4 \times 10^{-10}$ m;
same/similar wavelength to (b) (so de Broglie hypothesis supported); ***[4]***
*Allow **[3 max]** if 1.22 missing – answer is then 0.162 nm.*

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 <u>and</u> 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) p.d. $= E\times$ height of thundercloud base;
$0.33\times10^{6}\times750$;
2.5×10^{8} V; ***[3]***

(ii) $\dfrac{2.5\times10^{8}\times1.2\times10^{7}\times\varepsilon_0}{750}$;
$=35$ C; ***[2]***

(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 Microwave radiation

(a) standing wave formed;
by superposition/interference of (forward) wave and reflected wave;
maximum where interference is constructive / minimum where interference is destructive;
maxima where waves in phase;
minima where waves are completely/180°/π/half wavelength out of phase; ***[4 max]***

(b) (i) $130\,\text{mm} \equiv 9$ half wavelengths;
$29\,\text{mm}$; ***[2]***

(ii) $f = \frac{c}{\lambda}$;
$= 10\,\text{GHz}$; ***[2]***

(c) place a metal grid/analyser between source and detector;
electric field vector (of the microwaves) vibrates in only one direction/plane;
rotate the metal grid/detector;
until minimum signal is detected; ***[3 max]***

or

electric field vector vibrates in only one direction/plane;
rotate transmitter through an angle;
need to rotate receiver through same angle to restore signal in transmitter;

B3. (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]***

(c) (i) 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]***

(ii) U-238 is present;
U-238 captures neutron (to produce plutonium); ***[2]***

(iii) plutonium is also fissionable/can be used as fuel for (fast breeder) reactor; ***[1]***

(d) (i) Q: is the energy transferred between the system and surroundings;
W: work done on/by system; ***[2]***

(ii) Q transferred from reactor to gas;
no change in volume therefore $W = 0$;
internal energy of gas increases;
Q transferred from gas to surroundings therefore internal energy of gas decreases; ***[4]***

(iii) entropy of the gas initially increases as energy transferred from the reactor;
entropy of the surroundings increases as energy transferred (from the gas);
entropy of gas decreases on cooling;
overall the entropy of the total system increases; ***[4]***

B4. Part 1 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 $= 2.0 \times 10^{-3} \times 140$;

final speed $= \dfrac{2.0 \times 10^{-3} \times 140}{5.6 \times 10^{-2} + 2.0 \times 10^{-3}}$;

$= 4.8\,\text{m s}^{-1}$ ***[2]***

Watch for incorrect mass values in equation.

(ii) initial kinetic energy of pellet + clay block $= \frac{1}{2}mv^2$;

$0.5 \times 0.058 \times 4.8^2$ $(= 0.67\,\text{J})$;

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.* $a = \dfrac{u^2 - v^2}{2s}$;

$a = \dfrac{4.8^2}{2 \times 2.8}$;

$F = \dfrac{0.058 \times 4.8^2}{2 \times 2.8}$;

$= 0.24\,\text{N}$;

(c) (i) use of kinematic equation to yield time;

$t=\sqrt{\frac{2s}{g}}(=0.42\,\mathrm{s})$;

$s=$ horizontal speed $\times$ time;

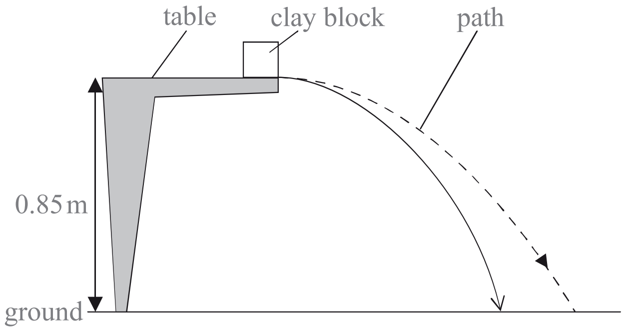
$=1.8\,\mathrm{m}$; ***[4]***

Accept $g=10\,\mathrm{m\,s^{-2}}$ equivalent answers 1.79 from 9.8, 1.77 from 10.

(ii) initial drawn velocity horizontal; *(judge by eye)*

reasonable shape;

horizontal distance moved always decreasing when compared to given path / range less than original; ***[3]***



Part 2 Gravitational field of Mars

(a) work done in moving mass from infinity to a point; ***[1]***

(b) (i) read offs –12.6 and –3.2;
gain in gpe $1.2\times10^{4}\times[12.6-3.2]$ ***or*** gain in g potential $\left[12.6\times10^{6}-3.2\times10^{6}\right]$;
$=1.13\pm0.05\times10^{5}$ MJ ***or*** $=1.13\pm0.05\times10^{11}$ J ; ***[3]***

(ii) <u>use of gradient of graph</u> to determine g;
values substituted from drawn gradient $\left(\text{typically } \dfrac{6.7\times10^{6}}{7\times3.3\times10^{6}}\right)$;
$=0.23\,\text{N kg}^{-1}$ *(allow answers in the range of 0.20 to 0.26 N kg*$^{-1}$*)* ***[2]***
*Award **[0]** for solutions from* $\dfrac{V}{r}$.

(c) g at surface $=4^{2}$ g at $4R$;
and $\dfrac{3.7}{0.23}=16.1$ ***or*** $16\times0.23=3.7\,\text{N kg}^{-1}$; ***[2]***

(d) escape speed for Earth > escape speed for Mars;
potential less/more negative at Earth; ***[2]***