N09/4/PHYSI/HP2/ENG/TZ0/XX/M+

International Baccalaureate®
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MARKSCHEME

November 2009

PHYSICS

Higher Level

Paper 2

16 pages

General Marking Instructions

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 **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. 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.

9. 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.

10. 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*

SECTION A

A1. (a) both error bars of $\pm 5\,\text{m}\,\text{s}^{-1}$ drawn correctly; ***[1]***

(b) a <u>straight</u> line cannot be drawn through the error bars; *Accept the error bar comment with a straight line drawn on graph.*

that goes through the origin; ***[2]***

(c) (i) $\pm 500\,(\text{m}^2\,\text{s}^{-2})$; ***[1]***

(ii) $\dfrac{\Delta\ v^2}{v^2} = 2\dfrac{\Delta v}{v}$;

$\Delta\ v^2 = 27^2 \times 2 \times \dfrac{5}{27}$;

$\Delta\ v^2 \approx (\pm)300\,(\text{m}^2\,\text{s}^{-2})$ ***or*** $\approx (\pm)270\,(\text{m}^2\,\text{s}^{-2})$; ***[3]***

or

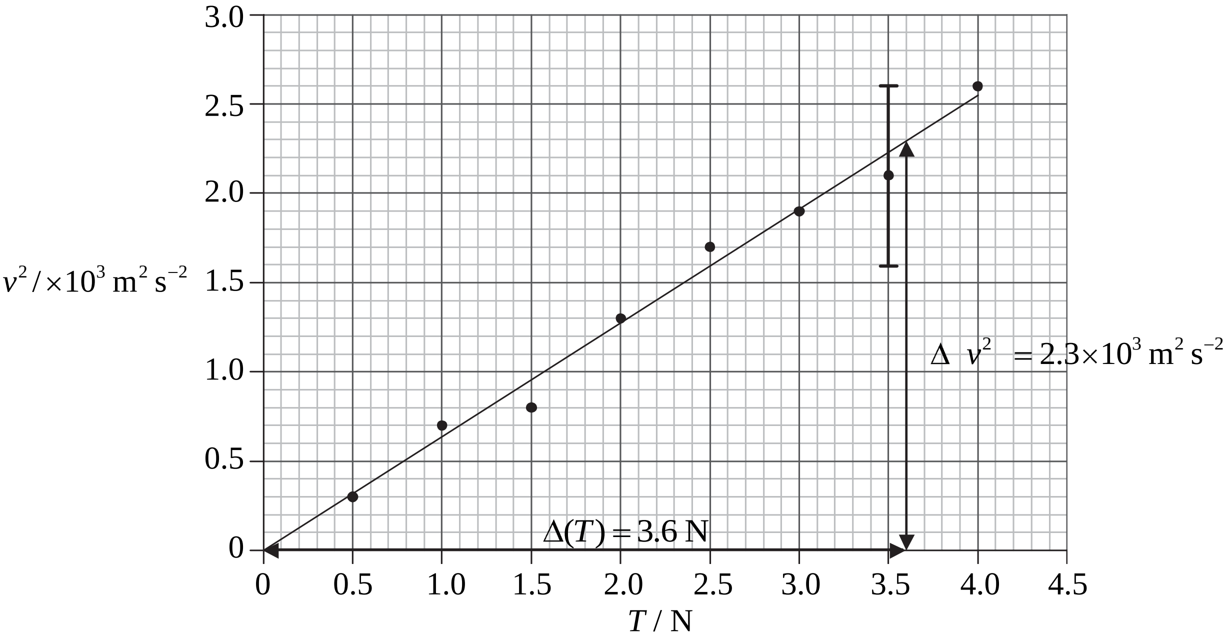
percentage error/uncertainty in $v = (18.5 =)\,19\%$;

percentage of error/uncertainty in $v^2 = 37\,\%$;

absolute error $\approx (\pm)300\,(\text{m}^2\,\text{s}^{-2})$ ***or*** $\approx (\pm)270\,(\text{m}^2\,\text{s}^{-2})$;

Answer must be to one or two significant figures.

(d)



use of gradient triangle over at least half of line;

gradient $= 640(\pm 40)$;

$= k^2$ to give $k = \sqrt{640} = 25(\pm 1)$;

unit of k is $\text{kg}^{-\frac{1}{2}}\ \text{m}^{\frac{1}{2}}$ ***or*** $\text{m}\,\text{s}^{-1}\,\text{N}^{-\frac{1}{2}}$; ***[4]***

Do not penalize omission of factor of 1000 for missing y-axis label if already penalized in (c). Treat as ecf.

A2. (a) (i) (thermal) energy/heat required to change temperature by 1 K/1 deg/1°C / mass $\times$ specific heat capacity; ***[1]***

(ii) rate of energy absorption is equal to the rate of energy emission / temperature of copper stays constant; ***[1]***

(b) (i) use of $mc\Delta T$;
$0.12 \times 390 \times [T - 308] = 0.45 \times 4200 \times 30$;
$1520\,\text{K}$ / $1250\,°\text{C}$; ***[3]***

(ii) energy likely to have been lost when moving copper / during warming of water;
hence temperature of flame higher; ***[2]***

A3. (a)

Symbol	*Gravitational field quantity*	*Electrical field quantity*
Y	field strength	field strength;
K	(universal) gravitational constant	$\frac{1}{4\pi\varepsilon_0}$ ***or*** Coulomb constant;
X	mass	charge;
s	distance from mass	distance from charge;

[4]

*Award **[1]** for a correct gravitational and electrical field quantity in each row.*

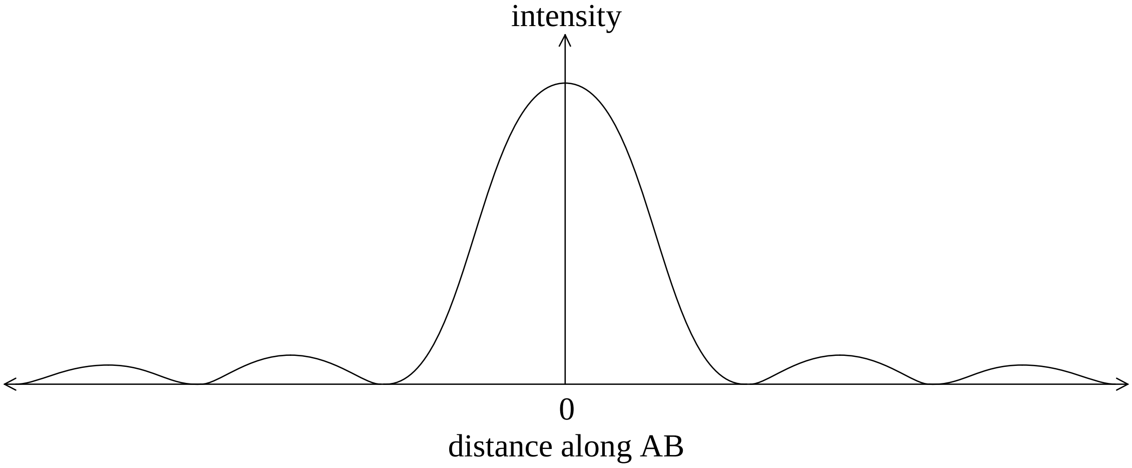
(b) identifies F_g ***or*** $\frac{6.7\times10^{-11}\times9.1\times10^{-31}\times1.7\times10^{-27}}{r^2}$;

identifies F_e ***or*** $\frac{\left[1.6\times10^{-19}\right]^2}{\varepsilon_0 4\pi r^2}$;

$(2.3)\times10^{39}$; ***[3]***

*Allow **[1 max]** for correct algebraic solution that does not insert numbers.*

A4. (a) (i) *Graph to show*



subsidiary maxima equally spaced;
width of subsidiary maxima half central maximum by eye;
height of subsidiary maxima to be at most a quarter of maxima; ***[3]***
*Award **[2 max]** if graph does not touch the x-axis.*

(ii) *effect*: broader maxima / pattern wider apart;
explanation: $\theta \propto \frac{1}{\text{slitwidth}}$ so angular width increases as slit width decreases;

effect: pattern dimmer / less intense;
explanation: less energy/intensity/amplitude after slit; ***[4]***

(b) no energy/amplitude/intensity/vibrations at nodes / food at nodes would not be heated;
food moves through nodes/regions of variable power / *OWTTE*;
evens out heating; ***[3]***

A5. (a) $T = mg \ (= 770 \times 9.8) = 7500\,\text{N}$; ***[1]***

Accept use of $g = 10$ *to yield 7.7 kN.*

(b) (i) (conservation of energy) leading to $v = \sqrt{2gh}$;

$= 5.6\,\text{m s}^{-1}$ ***or*** $5.7\,\text{m s}^{-1}$; ***[2]***

Accept use of $g = 10$. *Do not allow solutions from* $v^2 = u^2 + 2as$.

(ii) use of $\frac{mv^2}{r}$;

$= 2000\,(\text{N})$;

$T = (2000 + 7500 =)\,9500\,\text{N}$; ***[3]***

(c) (i) impulse / change in momentum; ***[1]***

(ii) use of $F\Delta t = \Delta p$ ***or*** $\Delta p = 5.60 \times 770 = 4312\,(\text{Ns})$;

$\frac{1}{2}F_{\text{max}} \times 0.15 = 4312$;

$F_{\text{max}} = 57\,\text{kN}$; ***[3]***

SECTION B

B1. (a) (i) $\text{mass} = 50 \times 5.0 \times 10^4 \times 10^3$;

loss in gpe $= 50 \times 5.0 \times 10^4 \times 10^3 \times 310 \times 9.81$; *Accept use of 335 m (including centre of mass of tank water) accept $g = 10$.*

7.6×10^{12} (J);

$\approx 8 \times 10^{12}$ (J) **[3]**

Do not penalize if the first marking point is incorporated into the second marking point.

(ii) flows for 6250 s;

1.2×10^9 W ***or*** 1.3×10^9 W; **[2]**

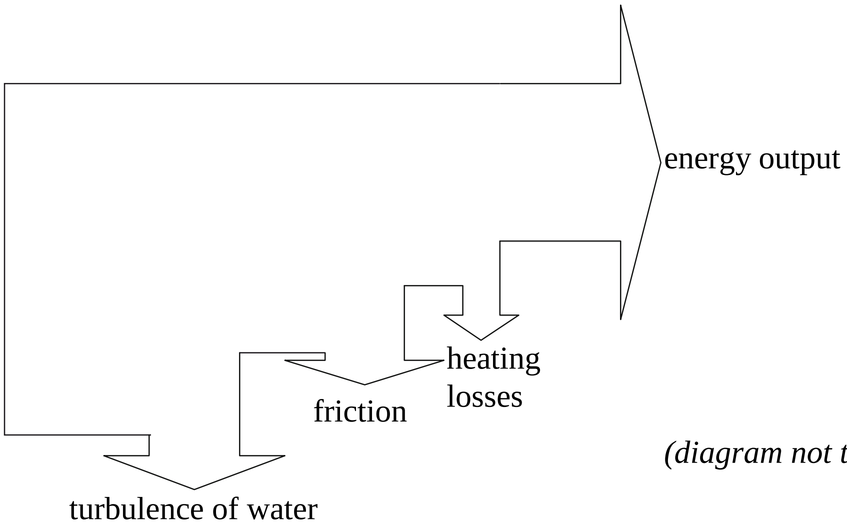
Accept solution from (a)(i) or from flow rate.

(b) (i) 53%; **[1]**

(ii) losses in correct order and approximately correct ratio of size;

arrows correctly labelled with source of loss; **[2]**

Labelling of width in % is acceptable for correct ratio only.



(diagram not to scale)

(c) (i) emf is proportional to rate of change of flux (linkage);
position 2 XY is moving perpendicular to field lines/position 1 is moving parallel to field lines;
rate of change is flux is greatest in position 2 / rate of change is less in position 1 than position 2; ***[3]***
Accept argument in terms of force on electrons.

(ii) $\varepsilon = 0.015 \times 1.5 \times 160$;
$3.6\,\text{V}$; ***[2]***

(iii) recognizes that coil has two sides;
$11\,\text{kV}$; ***[2]***
Award ***[1 max]*** *for 5.4 kV (only one side considered).*

(d) (i) transmit at high/increased potential difference/voltage;
use (step-up) transformer to (increase potential difference/voltage and) reduce current;
lower current means I^2R/resistive losses reduced;
large cable cross-section/good conductor used for cables so resistive losses reduced; ***[3 max]***
Do not accept discussion of reduction of station distance from consumer.

(ii) *advantage*: pumped storage on demand;
disadvantage: but needs to be re-stored before re-use; ***[2]***
Answer must focus on comparison between tidal and pumped storage.
Do not accept arguments based on unreliability of tide or installation costs

(e) (i) total volume of ice $= 14 \times 10^{12} \times 1.5 \times 10^{3}\,\text{m}^3$;
mass $= 2.1 \times 10^{16} \times 920 = 1.9 \times 10^{19}\,\text{kg}$; ***[2]***

(ii) new volume $1.9 \times 10^{16}\,\text{m}^3$;
level change $= \dfrac{\text{new volume}}{\text{area of ocean}}$;
$51\,\text{m}$; ***[3]***

B2. Part 1 Nuclear fission and fusion

(a) (i) the energy released when nuclides form from constituents / energy required to separate nucleus into separate nucleons / *OWTTE*; ***[1]***

(ii) S marked at maximum of curve (on curve/axis); *(judge by eye)* ***[1]***

(iii) highest binding energy per nucleon; ***[1]***

(b) (i) uranium binding energy per nucleon $= 7.6\,(\text{MeV})\ (\pm 0.1)$;
total uranium binding energy $= 7.6 \times 235 = 1786\,(\text{MeV})$;
total Kr + Ba binding energy $= 141 \times 8.4 + 92 \times 8.7 = 1985\,(\text{MeV})$;
energy released $= 1985 - 1786 = 198.8\,(\text{MeV})$;
$\simeq 200\,\text{MeV}$ ***[4]***

(ii) 2; ***[1]***

(iii) one reaction: $\Delta E = 3.1 \times 10^{-28} \times \left[3 \times 10^{8}\right]^{2} \left(= 2.8 \times 10^{-11}\,\text{J}\right)$;
number required $= \dfrac{1000}{2.8 \times 10^{-11}} = 3.6 \times 10^{13}$; ***[2]***

(iv) two neutrons produced may cause two further fissions;
producing four neutrons which may produce four further fissions; ***[2]***
*Accept answer in diagram form but it must feature four generated neutrons with **only** two neutrons giving further fission.*

(c) nuclear fusion waste much less active than fission waste;
fusion fuel much more abundant than fission fuel;
fusion fuel has higher energy density than fission;
radiation/pollution from plant lower for fusion; ***[3 max]***

Part 2 Charged-coupled devices (CCD)

(a) images must be at least two pixels apart / *OWTTE*; **[1]**

(b) (i) area of CCD $= 3.8 \times 10^{-4}\ \text{m}^2$;

size of pixel $= \sqrt{\dfrac{3.8 \times 10^{-4}}{10.2 \times 10^{6}}}$;

$= 6.1 \times 10^{-6}\ \text{m}$ **[2]**

(ii) number of photons $= 1.6 \times 10^{8} \times 0.8 = 1.28 \times 10^{8}$;

charge $= 1.28 \times 10^{8} \times 1.6 \times 10^{-19} \times 0.012 = 2.5 \times 10^{-13}$;

$V = \left(\dfrac{2.5 \times 10^{-13}}{3.5 \times 10^{-11}} = \right) 7.0\,\text{mV}$; **[3]**

(iii) separation on CCD $= 2.5 \times 2.2 \times 10^{-6} = 5.5\,\mu\text{m}$;
this is less than pixel size / $6\,\mu\text{m}$ so not resolved; **[2]**

(c) higher retrieval speed;
more portable;
more reproducible;
easily manipulated; ***[2 max]***
Do not award marks for references to quality.

B3. Part 1 Simple harmonic motion

(a) 1. acceleration proportional to displacement from equilibrium/centre (of motion) /mean position;
2. acceleration directed to equilibrium/centre/mean position; ***[2]***

(b) (i) $\frac{d}{2}$; ***[1]***

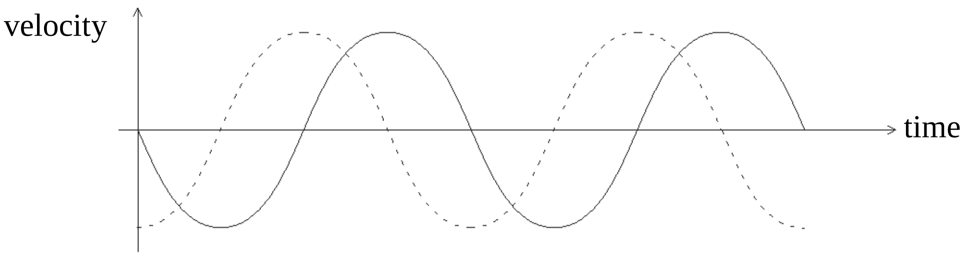
(ii) sine/cosine curve shape reasonable; ***[1]***
Do not allow semi-circle for half sine curve.

(iii) period labelled;
amplitude labelled; ***[2]***

(c) (i) $v = a2\pi f$ seen/used;
$3.3\,\mathrm{m\,s^{-1}}$; ***[2]***

(ii) $\text{acceleration} = a4\pi^2 f^2$ seen/used;
$9.2\times10^3\,\mathrm{m\,s^{-2}}$; ***[2]***

(d) cosine with the same period;
negative cosine;
Accept any amplitude.



[2]

Amplitudes need not be the same.

(e) (i) (a situation in which) a (resistive) force opposes the motion / the amplitude decays with time; ***[1]***

(ii) energy lost to surroundings / air resistance / frictional force is acting on the fork; ***[1]***

Part 2 Thermodynamics

(a) *Q*: thermal energy transfer to system;
ΔU: change in/difference in internal energy;
W: work done by system; ***[3]***
Accept valid alternative is "transfer from" **and** *"done on".*

(b) (i) isochoric / isovolumetric; ***[1]***

(ii) in procedure 1 the gas expands against the atmosphere;
this requires extra work to be done;
internal energy change for gas is less;
temperature is a measure of internal energy; ***[4]***
Ignore references to return of gas to initial state.

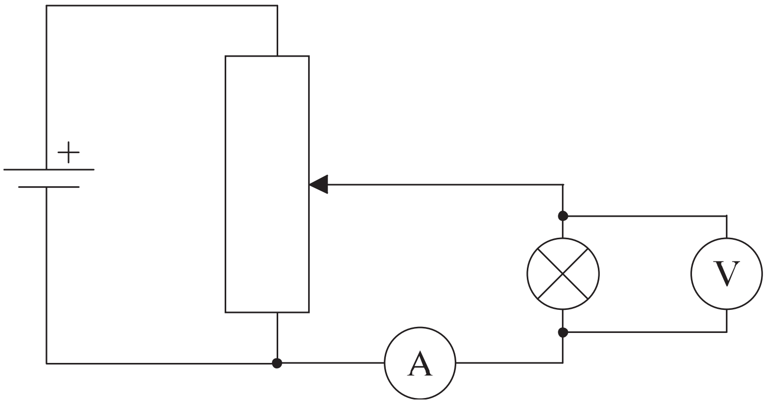
(iii)

	ΔU / J	*W / J*	*Q / J*
Procedure 1	*+120*	+80;	*+200*
Procedure 2	+200;	0;	*+200*

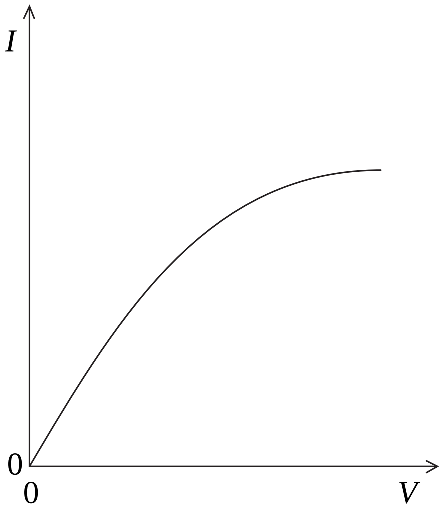
[3]

B4. Part 1 Electric circuits

(a) any circuit in which the current will flow through the lamp;
variable resistor connected as a potential divider;
voltmeter across lamp;
ammeter in series with lamp; ***[4]***



(b) correct shape;
through origin; ***[2]***



(c) $0.24\,\text{A}$; ***[1]***

(d) resistance calculated $= 5.2\,(\Omega)$;

$\text{A} = \left(\frac{\rho l}{R}\right) = 6.2 \times 10^{-8}\ \text{m}^2$;

radius $= \sqrt{\frac{A}{\pi}}$ seen/used;

$= 1.4 \times 10^{-4}\ \text{m}$; ***[4]***

(e) calculates resistance of lamps in parallel (2.6 Ω);
$V = \varepsilon - Ir$ used to give $V = 1.0\,\text{V}$;
1.0 V is lower than 1.25 V / power available to each lamp is 192 mW lower than 300 mW;
(terminal pd/power lower) hence not operating normally; $\Big\{$ *Award **[0]** for only stating this bald answer.* ***[4]***
Watch for ECF from (d).
*Award **[4 max]** for any correct numerical argument involving energy or power calculations.*

Part 2 Electrons

(a) (i) at certain angles the intensity of the scattered electrons was a maximum and at others a minimum;
suggesting that the electrons were interfering like waves; ***[2]***

(ii) combine $E = \frac{p^2}{2m}$ and $p = \frac{h}{\lambda}$;

$\lambda = \frac{h}{\sqrt{2emV}}$;

$\lambda = 1.7 \times 10^{-10}\ \text{m}$; ***[3]***

or

use of $eV = \frac{1}{2}mv^2$ to find v;

$v = 4.4 \times 10^6\ (\text{m s}^{-1})$;

$\lambda = 1.7 \times 10^{-10}\ \text{m}$;

(b) the associated de Broglie wavelengths of the electron are the wavelengths of the standing wavelengths allowed by the box;

$\lambda = \frac{2l}{n}$ where l is length of box and $n = 1, 2, 3\ldots$;

energy of electron depends on its momentum;

de Broglie states that $p = \frac{h}{\lambda}$;

therefore energy is quantized; ***[5]***

or

the associated de Broglie wavelengths of the electron are the wavelengths of the standing wavelengths allowed by the box / *OWTTE*;

$\lambda = \frac{2l}{n}$ where l is length of box and $n = 1, 2, 3\ldots$;

$p = \frac{hn}{2l}$;

de Broglie states that $p = \frac{h}{\lambda}$;

$E = \frac{h^2 n^2}{8ml^2}$;