M13/4/PHYSI/HP2/ENG/TZ1/XX/M

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MARKSCHEME

May 2013

PHYSICS

Higher Level

Paper 2

15 pages

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.

2. Each marking point has a separate line and the end is shown 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 ***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. When marking indicate this by adding **ECF** (error carried forward) on the script.

10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

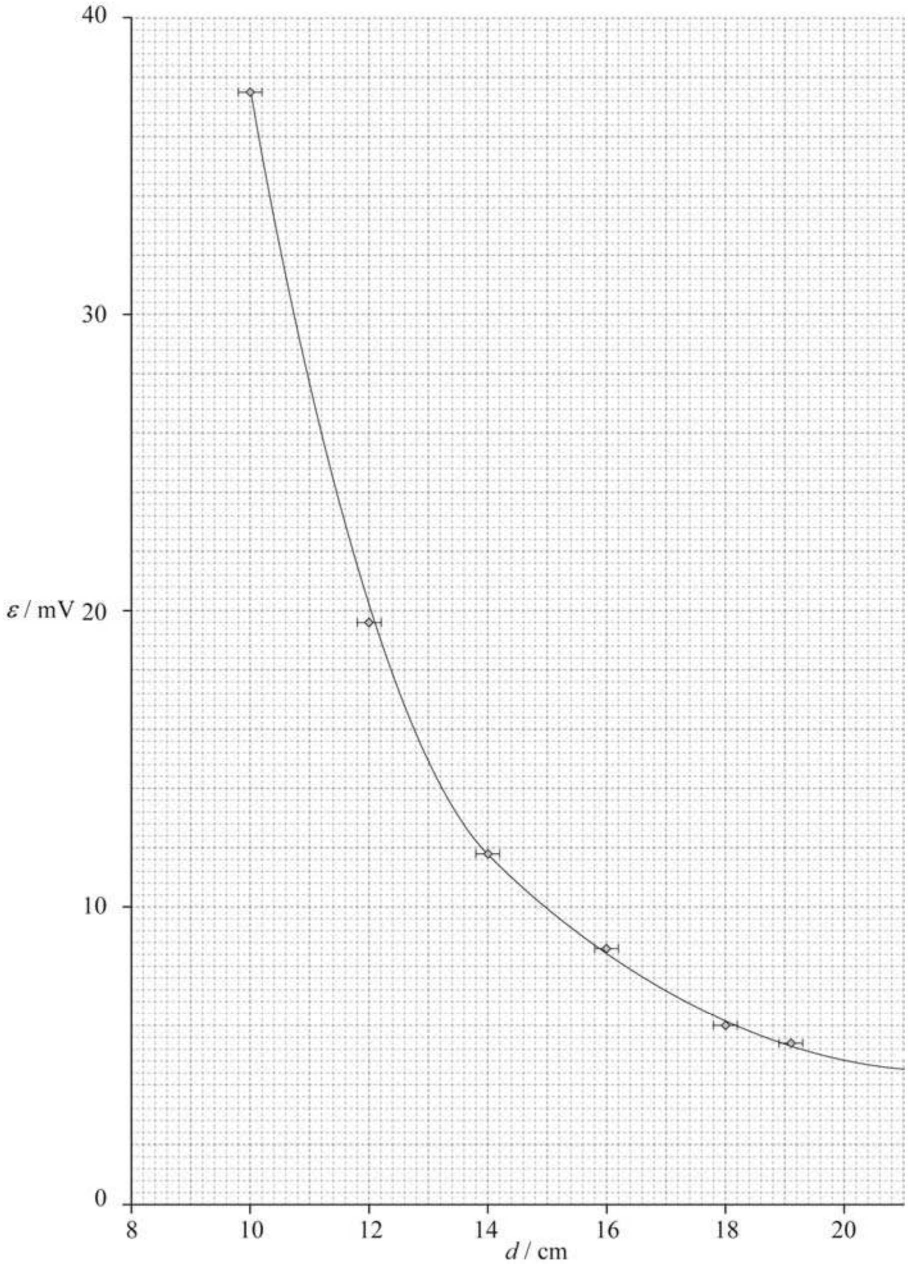
SECTION A

A1. (a) reference to meter/instrument;
reference to constant accuracy/precision; ***[2]***

(b) (i) point plotted $\pm\frac{1}{2}$ small square; ***[1]***

(ii) symmetrical error bar, 1 small square in each direction $\pm\frac{1}{2}$ small square; ***[1]***

(iii) single smooth curve within each error bar; ***[1]***



(c) % uncertainty in d value $\left(=\frac{0.2\,\text{cm}}{18\,\text{cm}}\right)=1/1.1\%$;

% uncertainty in $d\varepsilon$ product $=4/4.1\%$; **[2]**

(d) (i) metre^{-1}; **[1]**

Allow any SI prefix.

(ii) one axis $\log_e \varepsilon/\log_e(\varepsilon/a)$;

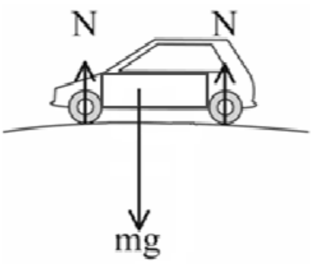
other axis d; **[2]**

(iii) $k=-$gradient/$-$reciprocal of gradient; **[1]**

A2. (a) direction changing;

velocity changing so accelerating; **[2]**

(b)



weight/gravitational force/mg/w/F_w/F_g and reaction/normal reaction/perpendicular contact force/N/R/F_N/F_R both labelled; *(do not allow "gravity" for "weight".)*

weight between wheels (in box) from centre of mass and reactions at both wheels / single reaction acting along same line of action as the weight; **[2]**

(c) $g=\frac{v^2}{r}$;

$v=\sqrt{50\times 9.8}$;

22 ms^{-1}; **[3]**

*Allow **[3]** for a bald correct answer.*

A3. (a) (when two similar waves meet) the resultant displacement is the (vector) sum of the individual displacements; ***[1]***
*Allow **[0]** for description in terms of amplitude.*

(b) (i) (constructive interference gives) amplitude $2A$;
intensity is proportional to square of total amplitude $(=4A^2)$; ***[2]***

(ii) attempted use of Pythagoras to measure path difference;
path difference $=0.55$ (m);
path difference $=\frac{\lambda}{2}$ (so out of phase / destructive interference); ***[3]***
Attempted use of Pythagoras may appear on diagram for (b)(i).

A4. (a) (i) (gravitational) potential energy (of club head) goes to kinetic energy (of club head);
some kinetic energy of club head goes to internal energy of club head/kinetic energy of ball; ***[2]***

(ii) equating mgh to $\frac{1}{2}mv^2$;
$v=4.1\ \text{m s}^{-1}$; ***[2]***

(b) deformation prolongs the contact time;
increased impulse => bigger change of momentum/velocity;

or

(club head) stores (elastic) potential energy on compression;
this energy is passed to the ball; ***[2]***

(c) (i) any value of $\frac{\text{mass}\times\text{velocity}}{\text{time}}$;
$1.3\times10^4\ \text{N}$; ***[2]***

(ii) $-1.3\times10^4\ \text{N}$; ***[1]***

(iii) clear use of conservation of momentum / impulse $=$ change of momentum;
$21\ \text{m s}^{-1}$;

or

$a=\left(\frac{\text{F}}{\text{m}}=\frac{-13000}{0.17}=\right)(-)\,76500\ \text{m s}^{-1}$;
$v=(u+at=38-76500\times0.00022=)\,21\ \text{m s}^{-1}$; ***[2]***

*Award **[2]** for a bald correct answer.*

A5. (a) (i) 32 mm; ***[1]***

(ii) period $= 160$ ms;
frequency $= 6.2/6.3$ Hz; ***[2]***
Allow ECF for incorrect period.

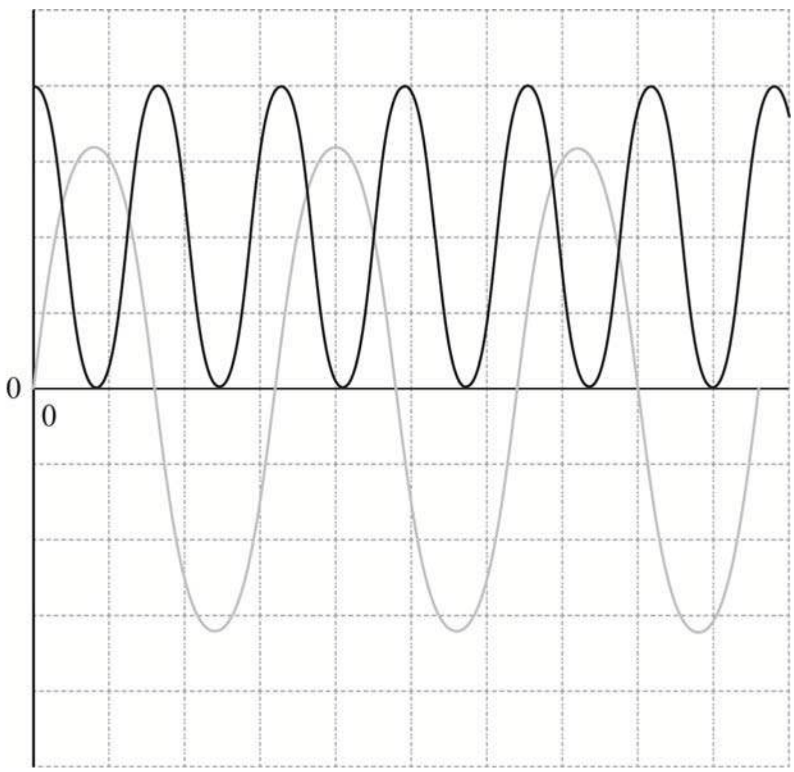
(b) (i) $\omega = 2\pi \times 6.25$;
$v(= 39.3 \times 32 \times 10^{-3}) = 1.3\ \text{m s}^{-1}$; *(allow ECF from (a))*

or

tangent drawn to graph at a point of zero displacement;
gradient calculated between 1.2 and 1.4; ***[2]***

(ii) displacement $= 23 - 26$ mm;
$35 - 40\ \text{m s}^{-2}$; ***[2]***

(c)



double frequency;
always positive and constant amplitude;
correct phase *ie* cosine squared; ***[3]***

A minimum of one complete, original oscillation needed to award ***[3]****.*

SECTION B

B1. Part 1 Electromagnetic induction

(a) (i) rate of change of flux (linkage) leads to induced emf (Faraday);
direction of emf tends to oppose the change (Lenz);
thus emf in one direction as magnet enters and in the opposite direction as it leaves coil;
magnet going faster so second peak larger;
magnet going faster so width of second peak is less; ***[3 max]***

(ii) attempted use of $\varepsilon = -N\dfrac{\Delta\varphi}{\Delta t}$;
recognition that the maximum pd is 0.8 V;
$\left(\dfrac{\Delta\varphi}{\Delta t} = -\dfrac{0.8}{1500} = -\right)5.3\times10^{-4}\ \text{Wb s}^{-1}$; ***[3]***

(b) (i) the value of the direct current (or voltage) that dissipates same power (in a resistor); ***[1]***
Do not allow $\dfrac{I_0}{\sqrt{2}}$ *etc.*

(ii) $I_0 = 396$ nA;
$V_0 = I_0 R = 0.59$ V; ***[2]***

(iii) damps oscillation / *OWTTE*;
dissipation of energy in coil/magnet; ***[2]***

Part 2 Nuclear fusion

(a) (i) difference in total mass of individual nucleons and nucleus / energy needed to divide nucleus into component nucleons / energy liberated when nucleus formed from component individual nucleons;
nuclear binding energy is the energy equivalent of mass defect / reference to $E = mc^2$; ***[2]***

(ii) S marked near line between 50 and 70; ***[1]***

(iii) binding energy per nucleon read from graph as 1.1/1.2 and 7.1/7.2 MeV;
both values multiplied by 4;
difference given between 23.6 and 24.4 MeV;
3.8×10^{-12} J ***or*** 3.9×10^{-12} J; ***[4]***

(b) (i) ${}^{1}_{1}\text{H}$ / ${}^{1}_{1}\text{p}$;
${}^{3}_{2}\text{He}$;
${}^{0}_{-1}\text{e}$ / ${}^{0}_{-1}\beta$;
${}^{0}_{0}\overline{\upsilon}$; (*do not allow neutrino)* ***[4]***

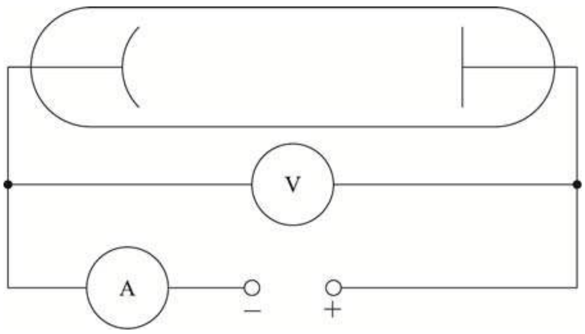
(ii) recognition that fusion process is more likely (at high temperatures);
the (electric) force between nuclei is repulsive;
nuclei need ~ 10^{-15} m separations for strong force to act;
kinetic energy of nuclei increases with temperature;
(higher temperature) increases probability of nuclear collisions;
radioactive decay is unaffected by temperature; ***[3 max]***

B2. Part 1 Photoelectricity

(a) minimum (photon) energy needed to eject electrons (from a surface); ***[1]***

(b) (i) apply stopping potential / *OWTTE*;
maximum kinetic energy $= eV$; ***[2]***

(ii)



power supply negative connected to detector;
ammeter and voltmeter correctly connected; ***[2]***
Allow voltmeter connected directly across power supply.

(c) (i) Planck constant = gradient; ***[1]***

(ii) work function = (–) intercept on maximum kinetic energy (*allow 'y'*) axis; ***[1]***

(iii) $\lambda_0 = \dfrac{c}{\text{frequency intercept}}$ ***or*** $\dfrac{hc}{\text{max ke intercept}}$; ***[1]***

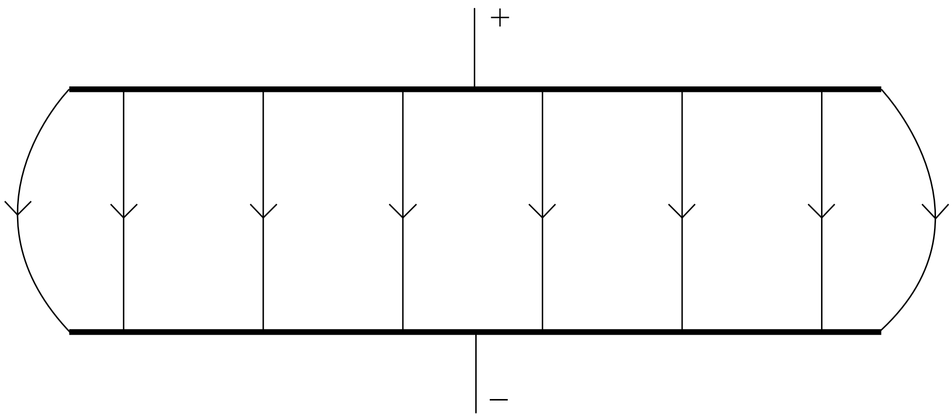
(d) more intense light means more photons per second;
so more electrons are ejected (per second); ***[2]***

Part 2 Electric and magnetic force fields

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

(b) (i) top plate positive and bottom negative (or +/− and ground); ***[1]***

(ii)



uniform (by eye) line spacing and edge effect, field lines touching both plates;
downward arrows (minimum of one and none upward); ***[2]***

(iii) $F = 2.5\times10^{3}\times1.6\times10^{-19}$;
4.0×10^{-16} N; ***[2]***
*Award **[2]** for a bald correct answer.*

(c) (i) use of $F = \dfrac{\left(1.60\times10^{-19}\right)^2}{4\pi\varepsilon_0\left(5.0\times10^{-3}\right)^2}$ ***or*** $F = \dfrac{\left(1.60\times10^{-19}\right)^2}{\left(5.0\times10^{-3}\right)^2}\times8.99\times10^{9}$;
9.2×10^{-24} N; ***[2]***

(ii) $1.0\times10^{7}\ \text{m s}^{-2}\left(9.9\times10^{6}\ \text{m s}^{-2}\ \text{if}\ 9\times10^{-24}\ \text{N used}\right)$; ***[1]***

(iii) electron will continue to accelerate;
speed increases with acceleration;
acceleration reduces with separation;
when outside the field no further acceleration/constant speed;
any reference to accelerated charge radiating and losing (kinetic) energy; ***[3 max]***

(iv) minimum of two concentric circles centred on Y;
anti-clockwise; ***[2]***

B3. Alternative energy supplies

(a) (i) mention of blades/propeller and turbine/generator/dynamo;
kinetic energy of wind → kinetic energy of turbine;
(rotational) kinetic energy → electricity/electrical energy; ***[3]***
*Award **[1 max]** for statement of (unqualified) kinetic energy to electrical energy.*

(ii) $A(=\pi r^2)=6.4\times10^3\,\text{m}^2$;
$(P=)$ 1.95 MW; ***[2]***

(iii) $0.24\times1.95\,\text{MW}$ (=0.47 MW/0.48 MW);
(0.47 MW=470 kW thus) two generators would meet the maximum demand; ***[2]***

(b) (i) sea is smoother (does not interrupt wind flow) / no obstacles on sea / less friction / less turbulence (vice versa for land) / *OWTTE*; ***[1]***
Allow named obstacles, eg trees/buildings/hills, etc.

(ii) $\frac{v_{land}}{v_{sea}}=\frac{10}{12.4}$;
$\frac{P_{land}}{P_{sea}}=\left[\frac{10}{12.4}\right]^3=0.52$; ***[2]***
*Award **[1 max]** for 1.9 due to inverted ratio.*

(c) photovoltaic cells generate emf/electricity;
solar panels generate thermal energy/heat / *OWTTE*; ***[2]***

(d) (i) emf = 3.0 V; ***[1]***

(ii) series combination of resistance $=7.2\Omega$;
use of parallel resistance formula;
2.4Ω; ***[3]***
*Award **[3]** for a bald correct answer.*

(iii) attempted use of IV, I^2R or $\frac{V^2}{R}$;
0.94 W; ***[2]***
Allow ECF from (d)(i) and (d)(ii).

(iv) (series) increases the total emf/voltage;
(parallel) increases the current/decreases internal resistance/ensures some power if single cell fails / *OWTTE*; ***[2]***

(e) (i) the solar radiation is captured by a disc of area πR^2 where R is the radius of the Earth;
but is distributed (when averaged) over the entire Earth's surface which has an area four times as large;

or

rays make an angle θ with area of Earth's half-sphere and so average intensity is proportional to average of $\cos^2\theta$ *ie* $\frac{1}{2}$;

there is an additional factor of $\frac{1}{2}$ due to the other half of the sphere; ***[2]***

(ii) variation of solar emission / Earth's orbit is elliptical/not quite circular; ***[1]***

(iii) input power needed $=\left(5\times 850\,\text{kW} =\right)4.25\times 10^6\ \text{W}$;

$\frac{4.25\times 10^6\ \text{W}}{3.5\times 10^2\ \text{W m}^{-2}} = 1.2\times 10^4\ \text{m}^2$; ***[2]***

Award ***[2]*** *for a bald correct answer.*

B4. Part 1 Gravitational force fields

(a) the (attractive) force between two (point) masses is directly proportional to the product of the masses;
and inversely proportional to the square of the distance (between their centres of mass); ***[2]***
Use of equation is acceptable:
*Award **[2]** if all five quantities defined. Award **[1]** if four quantities defined.*

(b) $G\frac{Mm}{R^2} = \frac{mv^2}{R}$ so $v^2 = \frac{Gm}{R}$;
$v = \frac{2\pi R}{T}$;
$(v^2 =)\frac{4\pi^2 R^2}{T^2} = \frac{Gm}{R}$;

or

$G\frac{Mm}{R^2} = m\omega^2 R$;
$\omega^2 = \frac{4\pi^2}{T^2}$;
$\frac{4\pi^2}{T^2} = \frac{GM}{R^3}$; ***[3]***
*Award **[3]** to a clear response with a missing step.*

(c) (i) $R^3 = \frac{6.67\times10^{-11}\times5.97\times10^{24}\times6000^2}{4\times\pi^2}$;

$R = 7.13\times10^6$ (m);
$h = \left(7.13\times10^6 - 6.37\times10^6\right) = 760$ (km); ***[3]***
*Award **[3]** for an answer of 740 with π taken as 3.14.*

(ii) clear use of $\Delta V = \frac{\Delta E}{m}$ and $V = -\frac{Gm}{r}$ ***or*** $\Delta E = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$;
one value of potential energy calculated $\left(2.37\times10^9 \text{ or } 2.02\times10^9\right)$;
3.5×10^8 (J); ***[3]***
*Award **[3]** for a bald correct answer.*

(iii) increased;
further from Earth / closer to infinity / smaller negative value; ***[2]***

Part 2 Properties of a gas

(a) (Q) energy transferred between two objects (at different temperatures);
(U) (total) potential energy and (random) kinetic energy of the molecules/particles (of the gas); ***[2]***

(b) (i) use of area within cycle;
each large square has work value of 250 J;
estimate $(16 \times 250 =) 4000$ J; *(allow 3600 – 4100)* ***[3]***

(ii) (work is done by the gas because) area under expansion is greater than that under compression/pressure during expansion is greater than during compression; ***[1]***

(iii) clear attempt to compare two PV values;
evaluate two PV values correctly *eg* $75 \times 80 = 6000$ and $200 \times 30 = 6000$; ***[2]***

(iv) use of $PV = nRT$ or equivalent;
1350/1330 K; ***[2]***

(v) both changes are isochoric/isovolumetric/constant volume changes;
B: temperature/internal energy increases, D: temperature/internal energy decreases;
B: thermal energy/heat input (to system), D: thermal energy/heat output (from system);
B: pressure increases, D: pressure decreases; ***[2 max]***