Markscheme

May 2015

Physics

Standard level

Paper 2

12 pages

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

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. 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.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, use the "ZERO" annotation to award zero marks. Where a candidate has not attempted the part question, use the "SEEN" annotation to show you have looked at the question. RM™ Assessor will apply "NR" once you click complete.

7. If a candidate has attempted more than the required number of questions within **Section B** (QIG 4), mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp "SEEN" on any additional pages that contain work not related to the QIG you are currently marking, or are blank or where the candidate has crossed out his/her work.

9. There is no need to stamp an annotation when a candidate has not chosen an optional question in **Section B** (QIG 4). RM™ Assessor will apply "NR" once you click complete.

10. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, 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.

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

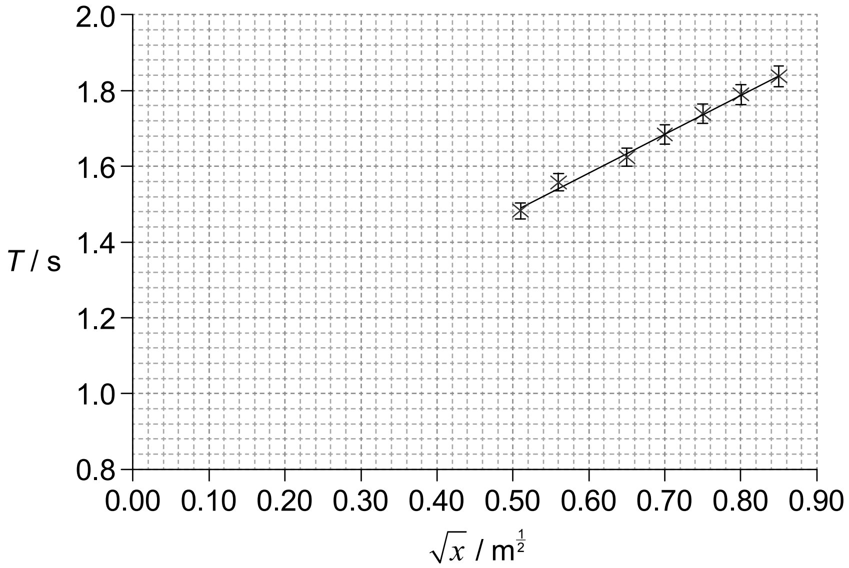
1. (a) fractional uncertainty in $l = \frac{1}{880}$ ***or*** 0.00114
and fractional uncertainty in $T = \frac{1}{19}$ ***or*** 0.0526; } *(both needed) (accept percentage, or fraction here – allow candidate to quote $\frac{2}{19}$ directly if added correctly later)*

fractional uncertainty in $g = (2 \times 0.0526 + 0.00114 =) 0.106$; } *(accept percentage, do not accept fraction)* **[2]**

(b) (i) half of cycle takes $\pi\sqrt{\frac{L}{g}}$ other half takes $\pi\sqrt{\frac{x}{g}}$ and combine to give result;

$\left(\frac{\pi}{g}\left(\sqrt{L}+\sqrt{x}\right)\right)$ **[1]**

(ii)



straight line of any length through all error bars; **[1]**
Do not accept kinked, fuzzy, doubled lines.

(iii) more than half line of their line used for gradient determination;
read-offs correct;
correct working leading to their gradient; *(best straight line gives 1.03)* **[3]**
At least two significant figures are required in answer.

(iv) their intercept ± half a square; *(best straight line gives 0.96 s)* **[1]**

(v) makes correct substitution for $T = 0$;
correct answer from own data including negative sign; } *(unit not required $-0.93\ m^{\frac{1}{2}}$)* **[2]**
*Allow substitution into equation for straight line, but data point used **must** lie on candidate line.*
N.B. *x in $y = mx + c$ is $\sqrt{x}$ on the axis – give BOD if not clear but answer correct.*

(vi) L = candidate value for b(v)^2; } *(= 0.93^2 = 0.87 for best straight line. Allow ECF from (b)(v))* **[1]**

*The candidate value should be b(v)^2 – if value differs from this, award **[0]**.*
***N.B.** the experimental value of g from the data in this experiment is **not** 9.8 m s^{-2} so award **[0]** for use of this value.*

2. (a) (i) (weight) = $85 \times 9.81 (= 834\,\text{N})$; *(if 850 (N) seen, award this mark)*
component = $(834 \times \sin 19 =)\ 271$ (N); **[2]**
Allow use of g = 10 m s^{-2}. Answer is 277 (N).

(ii) component = $(834 \times \cos 19 =)\ 788$ (N); **[1]**
Allow use of g = 10 m s^{-2}. Answer is 804 (N).
Allow a bald correct answer.
Do not award ECF if cos used in (a)(i) and sin used in (a)(ii).

(b) total decelerating force = $271 + 250 (= 521\,\text{N})$;

acceleration = $(-)\dfrac{521}{85}(= -6.13\,\text{m s}^{-2})$;

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

2.47 (m); } *(signs must be consistent for this mark, ie: if acceleration assumed positive, look for negative distance)* **[4]**

Allow use of g = 10. Answers are 527 N, 6.2 m s^{-2}, 2.44 m.

or

total decelerating force = $271 + 250 (= 521\,\text{N})$;

initial kinetic energy $= \dfrac{1}{2}mv^2 = 1290$ J;

distance = $\dfrac{\text{energy lost}}{\text{force}} = \dfrac{1290}{521}$;

2.47 (m);

3. (a) heat/thermal energy is the sum of PE and KE in a body / heat/thermal energy is flow/transfer of energy;
temperature is measure of average KE of particles / indicates direction of heat flow;
temperature is measured in K **and** thermal energy measured in J; *(both needed)* **[3]**

(b) (i) mass lost in 300 s = (1.880 − 1.580) = 0.3 (kg);
(energy supplied = 750 kJ) *(do not award credit for this line)*
L = 2.5 MJ kg^{-1}; *(unit must appear correctly here)* **[2]**
*Award **[2]** for a bald correct answer.*

(ii) energy will be transferred to surroundings; } *(accept energy is lost by/from kettle to surroundings)*

so calculated energy to water is too large / change in mass too large;
(hence overestimate) **[2]**
*Award **[0]** for a bald correct answer.*
Treat references to energy gained by kettle as neutral; the kettle is at a constant temperature.

Section B

4. Part 1 Renewable energy

(a) (i) total wind power required $= \frac{750\,000}{0.3}$;

maximum wind power required per turbine, $P = \frac{750\,000}{5 \times 0.3}$ $(= 500\text{ kW})$;

$d = \left(\frac{8P}{\rho \pi v^3} = \right)^{\frac{1}{2}} 40\text{ (m)}$; **[3]**

*Award **[1 max]** for an answer of 48.9 (m) as it indicates 5 and 0.3 ignored.*
*Award **[2 max]** for 22 (m) as it indicates 0.3 ignored.*
*Award **[2 max]** for 89 (m) as it indicates 5 ignored.*

(ii) not all kinetic energy can be extracted from wind / losses in cables to community / turbine rotation may be cut off/"feathered" at high or low wind speeds; **[1]**
Do not allow "wind speed varies" as question gives the average speed.

(iii) less kinetic energy available / wind speed less for turbines behind;
turbulence/wake effect; *(do not allow "turbines stacked too close")* **[2]**

(iv) *implications*: average wind speeds are greater / more space available;

limitations: installation/maintenance cost / difficulty of access / wave damage; **[2]**
*Must see one each for **[2]**.*

(b) (i) mass of coal per second $(= 0.0214\text{ kg})$;
77.1 (kg); **[2]**

or

energy saved per hour $= 0.75 \times 3600$ $(= 2700\text{ MJ h}^{-1})$;

mass of coal saved $= \left(\frac{2700}{35} = \right) 77.1\text{(kg)}$;

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

(ii) *advantage*:
energy is free (apart from maintenance and start-up costs) / energy is renewable / sufficient for small community with predominance of wind / supplies energy to remote community / independent of national grid / any other reasonable advantage;
Answer must focus on wind farm not coal disadvantages.

disadvantage:
wind energy is variable/unpredictable / noise pollution / killing birds/bats / large open areas required / visual pollution / ecological issues / need to provide new infrastructure; **[2]**

(iii) greenhouse gas molecules are excited by/absorbed by/ resonate as a result of infrared radiations; *(must refer to infrared not "heat")*

this radiation is re-emitted in all directions;

less greenhouse gas means less infrared/heat returned to Earth; *(consideration of return direction is essential for mark)*

temperature falls (to reach new equilibrium); **[3 max]**

Part 2 Nuclear energy and radioactivity

(c) energy released when a nucleus forms from constituent nucleons / (minimum) energy needed/work done to break a nucleus up into its constituent nucleons; **[1]**
*Award **[0]** for energy to assemble nucleus.*
Do not allow "particles" or "components" for "nucleons".
Do not accept "energy that binds nucleons together" OWTTE.

(d) (i) generally correct shape with maximum shown, trending down to U-235;
maximum shown somewhere between 40 and 70; **[2]**
*Award **[0]** for straight line with positive gradient from origin.*
*Award **[1]** if maximum position correct but graph begins to rise or flatlines beyond or around U-235.*

(ii) identifies fission as occurring at high nucleon number / at right-hand side of graph;
fission means that large nucleus splits into two (or more) smaller nuclei/nuclei to left of fissioning nucleus (on graph);
(graph shows that) fission products have higher (average) binding energy per nucleon than U-235;
energy released related to difference between initial and final binding energy; **[3 max]**
*Award **[2 max]** if no reference to graph.*

(e) (i) ${}^{235}_{92}\text{U} \rightarrow {}^{231}_{90}\text{Th} + {}^{4}_{2}\alpha$; *(allow He for α; treat charge indications as neutral)* **[1]**

(ii) time taken for number of unstable nuclei/(radio)activity to halve; **[1]**
Accept atom/isotope.
Do not accept mass/molecule/amount/substance.

(iii) three half-lives identified;
45 (mg); **[2]**
*Award **[2]** for bald correct answer.*

5. Part 1 Simple harmonic motion (SHM)

(a) $ma = -kx$;

$a = -\frac{k}{m}x$; *(condone lack of negative sign)*

$\left(\omega^2 = \frac{k}{m}\right)$ **[2]**

or

implied use of defining equation for simple harmonic motion $a = -\omega^2 x$;

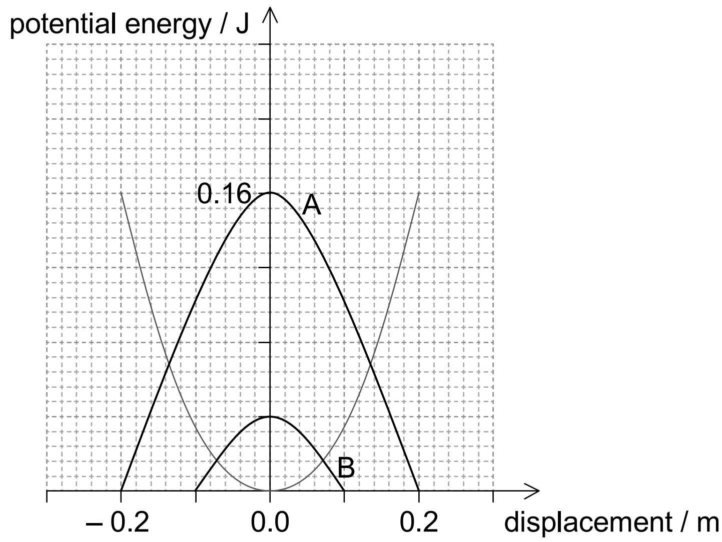
$\left(\text{so } \omega^2 = \frac{k}{m}\right)$

$ma = -kx$ so $a = -\left(\frac{k}{m}\right)x$;

(b) (i) 0.833 (Hz); **[1]**

(ii) frequency/period is the same so ω is the same;
k is the same (as springs are identical);
(so m is the same) **[2]**

(c) (i)



correct shape;
maximum at 0.16 J; **[2]**

(ii) end displacements correct ±0.01 m;
maximum lower than 0.16 J;
maximum equal to 0.04 J ± half square; **[3]**

Part 2 Current electricity

(d) (i) $l = \frac{\pi d^2 R}{4\rho}$ seen / correct substitution into equation: $24 = \frac{l \times 1.7 \times 10^{-8}}{\pi \times (0.15 \times 10^{-3})^2}$; *(condone use of r for $\frac{d}{2}$ in first alternative)*

99.7 (m); **[2]**

*Award **[2]** for bald correct answer.*
*Award **[1 max]** if area is incorrectly calculated, answer is 399 m if conversion to radius ignored, ie: allow ECF for second marking point if area is incorrect provided working clear.*

(ii) any line showing resistance decreasing with increasing diameter **and** touching point;
correct curved shape showing asymptotic behavior on at least one axis; **[2]**

(e) current/conduction is (related to) flow of charge;
conductors have many electrons free/unbound / electrons are the charge carriers / insulators have few free electrons;
pd/electric field accelerates/exerts force on electrons;
smaller current in insulators as fewer electrons available / larger current in conductors as more electrons available; **[3 max]**

(f) (i) use of total resistance = 11 Ω; *(can be seen in second marking point)*
$\frac{1}{11} = \frac{1}{R} + \frac{1}{24}$;
20.3 (Ω); **[3]**

(ii) as current is same in resistor network and cell and resistance is same, half of emf must appear across resistor network;
6.0 (V); **[2]**

or

$I = \frac{12}{(11+11)} = 0.545$ (A);
$V = (0.545 \times 11 =)$ 6.0 (V);
Other calculations are acceptable.
*Award **[2]** for a bald correct answer.*

(iii) use of 22 (ohm) ***or*** 11 + 11 (ohm) seen;
use of $\frac{V^2}{R}$ or equivalent;
6.54 (W); **[3]**
*Award **[3]** for bald correct answer.*
*Award **[2 max]** if cell internal resistance ignored, yields 3.27 V.*

6. Part 1 Momentum

(a) total momentum does not change/is constant; } *(do not allow "momentum is conserved")*

provided external force is zero / no external forces / isolated system; **[2]**

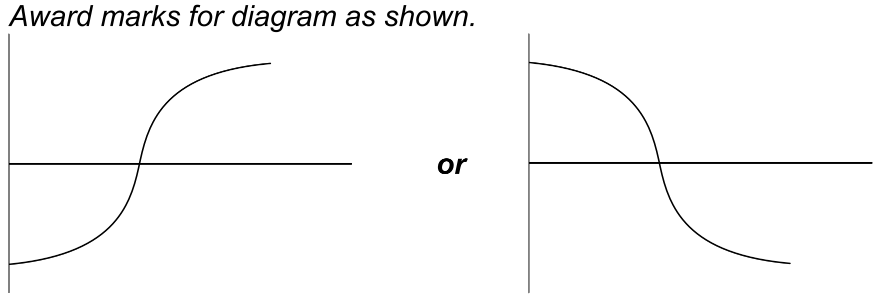
(b) (i) clear attempt to calculate area under graph;
initial momentum is half change in momentum;
$\left(\frac{1}{2}\times\frac{1}{2}\times 24\times 0.16\right)=0.96$ (kg m s^{-1}); **[3]**
*Award **[2 max]** for calculation of total change (1.92 kg m s^{-1})*

(ii) initial speed $=\left(\frac{0.96}{0.8}=\right)1.2\text{ m s}^{-1}$;
$a=\frac{1.2-(-1.2)}{0.16}$ ***or*** $a=\frac{-1.2-1.2}{0.16}$;
–15 (m s^{-2}); *(must see negative sign or a comment that this is a deceleration)* **[3]**

or

average force = 12 N;
uses $F=0.8\times a$;
–15 (m s^{-2}); *(must see negative sign or a comment that this is a deceleration)*
*Award **[3]** for a bald correct answer.*
Other solution methods involving different kinematic equations are possible.

(iii) goes through $t=0.08$ s **and** from negative momentum to positive / positive momentum to negative;
constant sign of gradient throughout;
curve as shown; **[3]**
Award marks for diagram as shown.



(c) impulse is the same/similar in both cases / momentum change is same;
impulse is force × time / force is rate of change of momentum;
time to come to rest is longer for car B;
force experienced by car B is less (so less likely to be damaged); **[4]**

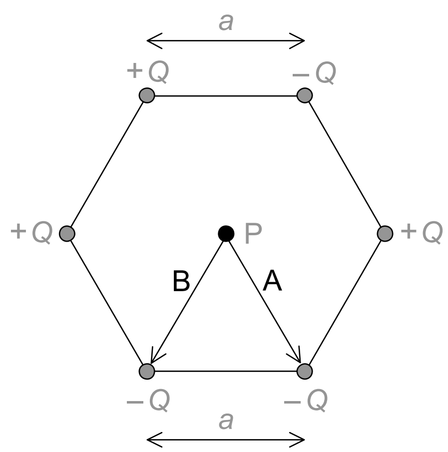
Part 2 Electrical point charges

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

(e) (i) states Coulomb's law as $\frac{kQq}{r^2}$ ***or*** $\frac{F}{q} = \frac{kQ}{r^2}$;

states explicitly $q = 1$;
states $r = a$; **[2 max]**

(ii)



arrow labelled A pointing to lower right charge;
arrow labelled B point to lower left charge; **[2]**
Arrows can be anywhere on diagram.

(iii) overall force is due to $+Q$ top left and $-Q$ bottom right / top right and bottom left and centre charges all cancel; } *(can be seen on diagram)*

force is therefore $\frac{2kQ}{a^2}$;

2.6×10^6 (N C^{-1}) ;
towards bottom right charge; *(allow clear arrow on diagram showing direction)* **[4]**