N12/4/PHYSI/SP2/ENG/TZ0/XX/M

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MARKSCHEME

November 2012

PHYSICS

Standard Level

Paper 2

13 pages

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

A1. (a) (i) both error bars correct (overall length 4 squares) $\pm \frac{1}{2}$ square; ***[1]***

(ii) smooth curve going through error bars and within half square of other points; ***[1]***

(b) not proportional because not straight/trend cannot go through origin; ***[1]***

(c) fractional error in $v = \frac{20}{250} (= 0.080)$;

fractional error in $v^{\frac{1}{3}} = \frac{0.080}{3} (= 0.027)$; *(allow ECF from first marking point)*

uncertainty in $v^{\frac{1}{3}} = (0.063 \times 0.027 =) 0.00169$; *(allow 0.00168 – 0.00170)*

Allow expression of answer as 0.630 ± 0.002 if calculation above seen.

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

or

recognizes uncertainty in $v^{\frac{1}{3}} = \frac{\sqrt[3]{270} - \sqrt[3]{230}}{2}$ ***or*** $\sqrt[3]{250} - \sqrt[3]{230}$ ***or*** $\sqrt[3]{270} - \sqrt[3]{250}$;

$= 0.168$;

conversion to $0.00168\ \text{m s}^{-1}$;

(d) (i) large triangle > half line used;

read-offs and substitution correct; *(allow power of ten error here)*

$k^{\frac{1}{3}} = 0.012 \pm 0.001$; *(allow ECF)*

$k = 1.73 \times 10^{-6}\ \text{m N}^{-3}\ \text{s}^{-1}$; *(allow correct power of ten only)* ***[4]***

*Award **[0]** for use of a single data point.*

(ii) $\text{m N}^{-3}\ \text{s}^{-1}$ ***or*** $\text{kg}^{-3}\ \text{m}^{-2}\ \text{s}^{5}$; ***[1]***

A2. (a) (electric current means) movement of charge; ***[1]***
Do not allow references to current alone – this is in the question.
Do not allow references to charges repelling.

(b) at least two concentric circles;
with clockwise direction indicated; ***[2]***

(c) (i) each turn subject to the magnetic field of the other / field patterns for individual turns combine;
force shown to be attractive by use of direction rule/ by consideration of field pattern / *OWTTE*; *(can be shown diagrammatically)* ***[2]***

(ii) $F = (0.280 \times 10^{-3} \times 9.81 =) 2.75 \times 10^{-3}$ N;
$B = \frac{F}{Il}$ ***or*** correct substitution $2.75 \times 10^{-3} = B \times (15) \times 0.48$;
$B = \left(\frac{2.75 \times 10^{-3}}{15 \times 0.48} = \right) 3.8 \times 10^{-4}$ T; ***[3]***

A3. (a) $^{137}_{56}\text{Ba}$;
anti-neutrino / $\bar{\nu}$; ***[2]***

(b) evidence of use of 4 half-lives;
so 0.938 ***or*** 93.8% ***or*** $\frac{15}{16}$ decays; ***[2]***

(c) reference to a short-term effect *e.g.* skin reddening / burning;
reference to a long-term effect *e.g.* genetic damage / cancer;
reference to relative penetrative power of beta/ionizing power compared to alpha or gamma; ***[2 max]***

SECTION B

B1. Part 1 Momentum change

(a) if no external forces act / isolated system;
momentum is constant / (total) momentum before = (total) momentum after; ***[2]***

(b) (i) use of $v = \sqrt{2gh}$;
$6.11\ \text{m s}^{-1}$; *(must show calculation to better than 1 sf)* ***[2]***

(ii) rate of change of vertical momentum $= 13 \times 6.11$;
79 N; *(accept answers in the range of 78 N to 80 N)* ***[2]***

(iii) mass accrued $= 5.0 \times 13 = 65\ \text{kg}$;
weight of this mass $(= 65 \times 9.8) = 637\ \text{N}$; *(650 from $g = 10\ \text{m s}^{-2}$)*
total force $= (637 + 79 =) 716\ \text{N}$; *(allow ECF from (b)(ii) and from incorrect weight)* ***[3]***

(c) (i) $14.6\ \text{J s}^{-1}$; ***[1]***

(ii) horizontal momentum gain per second $= 13 \times 1.5\ (= 19.5\ \text{kg m s}^{-1})$;
power required = 29.3 W; ***[2]***

(iii) additional energy/power required to accelerate gravel (through friction at the surface of the belt) / the gravel has to slip to gain horizontal speed / *OWTTE*; ***[1]***

Part 2 Oscillating water column (OWC) energy converter

(a) (i) tidal storage / wind turbine / *OWTTE*; ***[1]***
Do not allow "hydroelectric power".

(ii) mention of wave (as source of energy); *(do not allow reference to tide)*
water compresses air (already inside chamber);
air moves through a turbine;
turbine turns dynamo/generator; *(do not award this mark for discussion of energy, must see a clear idea that one turns the other)* ***[3 max]***

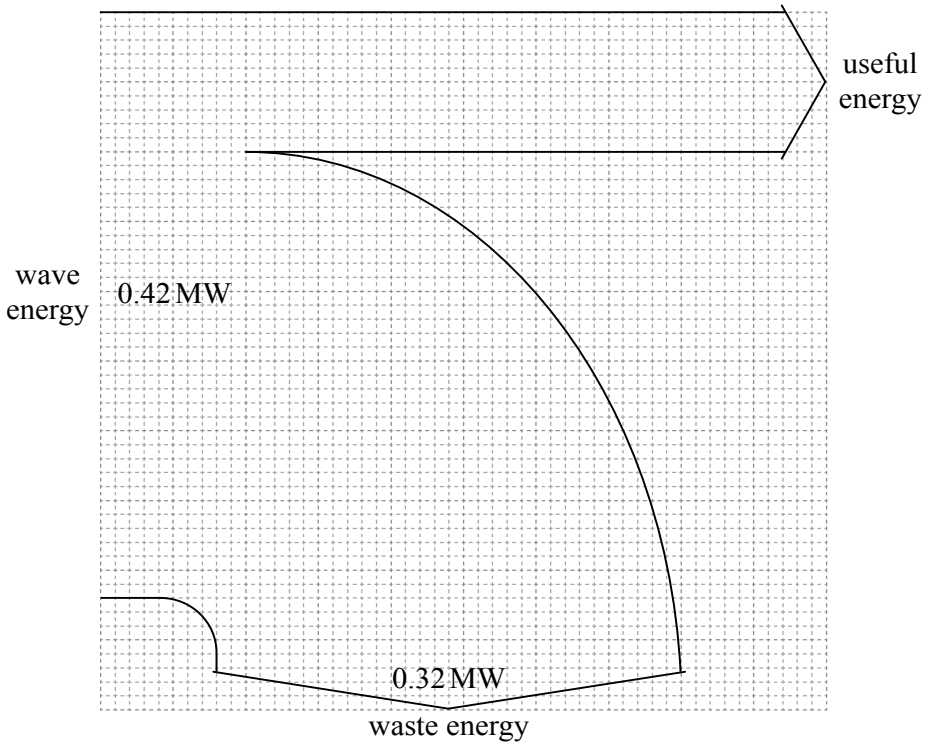
(iii) kinetic and (gravitational) potential energy of wave transferred to potential energy/kinetic energy of air; *(must see both energies for wave)*
(energy of air) transferred to kinetic energy of turbine;
kinetic energy of turbine transferred to electrical energy of dynamo/generator; ***[2 max]***

(b) (i) required wave power per unit width $= \frac{0.10 \div 0.24}{4.5} (= 0.093\,\text{MW})$;

wave speed $= \frac{95}{8} \left(= 11.9\,\text{m s}^{-1}\right)$;

use of $\frac{1}{2} A^2 \rho g v$ to give 1.3 m amplitude; ***[3]***

(ii) diagram correct shape (but scaled incorrectly) and labelled;
waste energy 0.32 MW; *(allow ECF from (b)(i))*
all dimensions scaled correctly (by eye); ***[3]***



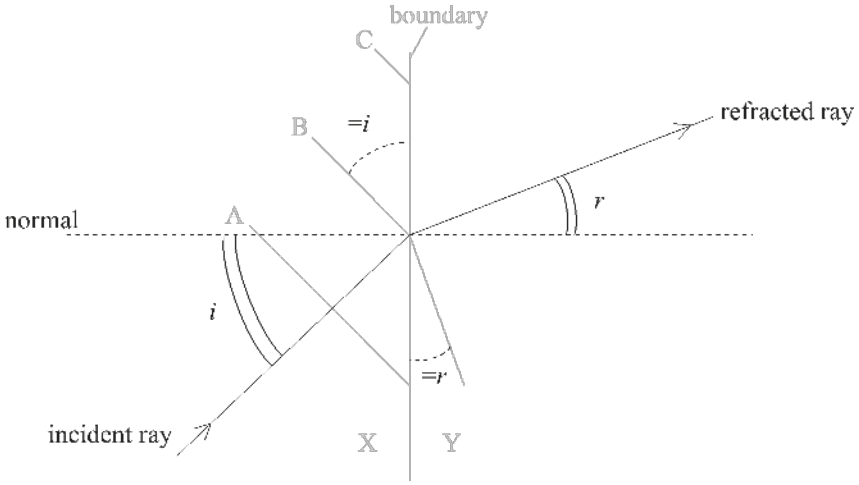
B2. Part 1 Wave motion

(a) *ray*: direction of wave travel / energy propagation;
wavefront: line that joins points with same phase/of same crest/trough;
ray normal/at right angles/perpendicular to wavefront; ***[3]***

(b) (i) line parallel to existing line in Y and continuous at boundary; *(both needed)* ***[1]***

(ii) measures "wavelength" correctly in media X and Y; } *(by eye)* } *(look for ratio of 0.5 : 1 in responses)*
$\frac{n_X}{n_Y} = \frac{\lambda_Y}{\lambda_X}$;
0.5 : 1; *(accept answers in the range of 0.47 to 0.53)* ***[3]***

or



justification that angles needed for calculation are either pair of *i* and *r* as shown and angles measured correctly;
$\frac{n_X}{n_Y} = \frac{\sin r}{\sin i}$;
0.5 : 1;

(c) mention of perpendicular/right angle/ 90°angle for transverse and parallel for longitudinal;
clear comparison between direction of energy propagation and direction of vibration/oscillation of particles for both waves; ***[2]***

(d) (i) time period = 6.0 ms;
167 Hz; ***[2]***

(ii) M where line crosses *x*-axis; ***[1]***

(iii) counts rectangles (14 ± 2) to first peak;
one rectangle equivalent to 0.5 mm;
7.2 mm; ***[3]***

or

$\omega = (2\pi f =) 330\pi$;

$a = \left(\frac{v}{\omega} =\right) \frac{7.5}{330\pi}$;

7.2 mm;

Allow any valid algebraic method, eg $v = \omega\sqrt{(x_0^{\,2} - x^2)}$.

Part 2 Melting of the Pobeda ice island

(a) (i) in water, molecules are able to move relative to other molecules, less movement possible in ice / in water, vibration and translation of molecules possible, in ice only vibration;
in liquid there is sufficient energy/vibration (from latent heat) to break and re-form inter-molecular bonds; ***[2]***

(ii) mass of ice $= 70000 \times 35000 \times 240 \times 920 (= 5.4 \times 10^{14}\,\text{kg})$;
energy to raise ice temperature to 0 °C $= 5.4 \times 10^{14} \times 2.1 \times 10^{3} \times 35 (= 3.98 \times 10^{19}\,\text{J})$;
energy to melt ice $= 5.4 \times 10^{14} \times 3.3 \times 10^{5} (= 1.8 \times 10^{20}\,\text{J})$;
total $= 2.2 \times 10^{20}\,\text{J}$ ***[3]***

(iii) energy incident $= 450 \times 70000 \times 35000 \left(= 1.1 \times 10^{12}\,\text{J s}^{-1}\,\text{m}^{-2}\right)$;
energy available for melting $= 1.1 \times 10^{12} \times 0.2 \left(= 2.2 \times 10^{11}\,\text{J}\right)$;
time $= \left(\frac{2.2 \times 10^{20}}{2.2 \times 10^{11}} =\right) 9.9 \times 10^{8}\,\text{s}$ ***or*** 32 years; ***[3]***

(b) average albedo of ocean much smaller than (snow and) ice;
so average albedo (of Earth) is reduced; ***[2]***

B3. Part 1 Lighting system

(a) providing the temperature/physical conditions are constant and pd ∝ current; ***[1]***

or

providing the temperature/physical conditions are constant and the resistance is constant;

(b) (i) current for one lamp = 1.5 A;
$\frac{13}{1.5} = 8.67$;
so 8; ***[3]***
Must show working for full credit. Allow any suitable method.

(ii) 4.0 Ω; ***[1]***

(iii) *estimate*:
resistance of incorrect lamp = 16 Ω;
total resistance of "correct" lamps in parallel = 1.3 Ω ***or*** $\frac{1}{R} = \frac{1}{16} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}$;
total resistance = 1.2 Ω;

assumption:
"incorrect" lamp will be at correct resistance/working temperature/normal brightness; ***[4]***

(c) LDR has higher resistance (than resistor) when dark/lower resistance when in light;
pd dropped across resistor and LDR in proportion to resistances;
high pd across lamp means high current (so intensity increases); ***[3]***
*Award **[2 max]** for current increases linked to decrease in resistance.*

Part 2 Satellite

(a) force is proportional to product of masses and inversely proportional to square of distance apart;
reference to point masses; ***[2]***

(b) (i) order of 1 cm; ***[1]***

(ii) $3\times10^{8}\times67\times10^{-3}$;
$2.0\times10^{7}\,\text{m}$; ***[2]***

(c) (i) force required towards centre of Earth to maintain orbit;
force means that there is an acceleration / *OWTTE*; ***[2]***

or

direction changes;
a change in velocity therefore acceleration;

(ii) uses $= \frac{GM}{r^2}$ ***or*** $\frac{6.7\times10^{-11}\times6.0\times10^{24}}{\left[2.6\times10^{7}\right]^2}$;
$0.57\,\text{N kg}^{-1}$; *(allow $m\,s^{-2}$)* ***[2]***

(iii) $v=\sqrt{0.57\times\left(2.0\times10^{7}+6.4\times10^{6}\right)}$ by equating $\frac{v^2}{r}$ and g;
$3900\,\text{m s}^{-1}$; ***[2]***

(iv) $T=2\pi\frac{2.6\times10^{7}}{3900}$;
11.9 hours; ***[2]***