Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2015

Physics

Standard level

Paper 2

11 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.

Section A

1. (a) smooth curve line through all error bars; **[1]**
Do not allow kinked or thick lines or double/multiple lines.
Ignore any line beyond the range of plotted points.
Assume a broken line is due to scan and allow BOD.
Line must go through vertical part of error bar. Do not allow line to clip horizontal endcaps.

(b) line (of best-fit) not straight/curved/changing gradient;
ratio of h to $T\times10^{-4}$ is not constant; **[1 max]**

(c) (i) $(\pm)1^{\circ}$ C/K/deg; *(do not allow 2 or more sig figs in the answer)* **[1]**

(ii) equal graduations / constant cross-section/capillary diameter / (volume of) liquid expands linearly/proportionally to T / *OWTTE*; **[1]**

(d) $\frac{\Delta h}{h}=\frac{0.01}{0.72}$ ***or*** 0.014 ***or*** 1.4 % <u>and</u> $\frac{\Delta T}{T}=\frac{1}{50}$ ***or*** 0.02 ***or*** 2 %; *(allow ECF from (c)(i))*
$\frac{\Delta K}{K}=3\times\frac{1}{50}+\frac{0.01}{0.72}$ ***or*** $=7.4\times10^{-2}$ ***or*** 7.4 %;
$K=5.8/5.76/6\times10^{-6}$;
$\Delta K=4\times10^{-7}\ \text{m K}^{-3}$ ***or*** $\text{m}\ {}^{\circ}\text{C}^{-3}$; *(1 sig fig **and** correct unit required)* **[4]**

2. (a) gravitational provides centripetal force / gravitational provides force towards centre;
(because radius is implied constant) (centripetal) force is constant;
at 90° to velocity (vector)/orbit/direction / *OWTTE* / $\frac{GmM}{r^2}=\frac{mv^2}{r}$ (or re-arranged) and therefore speed is constant (and motion is uniform); *(do not allow "inwards/centripetal" for this mark. The right angle must be explicit)* **[3]**

(b) $v=\omega r$ and $\omega=\frac{2\pi}{T}$ combined;
$v=\left(\frac{2\pi r}{T}=\right)\frac{2\pi\times9.4\times10^{6}}{7.7\times3600}$ ***or*** $2.1(3)\times10^{3}\ \text{m s}^{-1}$; **[2]**
Allow approach from speed $=\frac{s}{t}$, *do not allow approach from* $v^2=ar$ *or* $f=\frac{1}{T}$.

(c) $m\frac{v^2}{r}=G\frac{mM}{r^2}$ ***or*** $F_c=F_G$;
$M=\frac{v^2r}{G}$ ***or*** $\frac{(2.13\times10^{3})^2\times9.4\times10^{6}}{6.67\times10^{-11}}$;
$M=6.4\times10^{23}$ kg from 2.13 ***or*** 5.6×10^{23} kg from 2; **[3]**

3. (a) force/acceleration proportional to the displacement/distance from a (fixed/equilibrium) point/mean position;
directed towards this (equilibrium) point / in opposite direction to displacement/distance; **[2]**
Allow algebra only if symbols are fully explained.

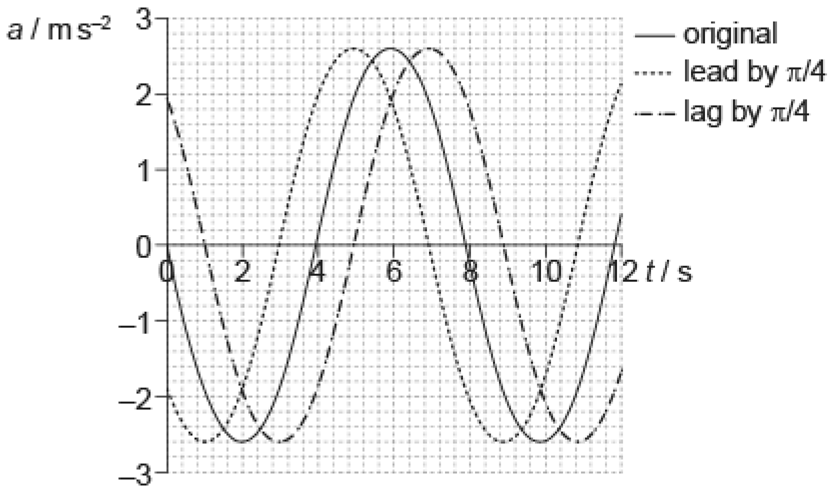
(b) 0.73 N; **[1]**

(c) use of $a_0 = -\omega^2 x_0$;

$T = 7.9$ s ***or*** $\omega = 0.795$ ***or*** $\frac{\pi}{4}$ rad s^{-1};

$x_0 = 4.1(1)$ m; *(allow answers in the range of 4.0 to 4.25 m)*
two significant figures in final answer whatever the value; **[4]**

(d) shape correct, constant amplitude for new curve, minimum of 10 s shown; *(there must be some consistent lead or lag and no change in T)*
lead/lag of 1 s (to within half a square by eye); **[2]**



Section B

4. Part 1 Nuclear model of the atom and radioactive decay

(a) most undeflected/pass straight through;
hence mostly empty space;
few deflected;
hence small dense nucleus;
positive / positively charged; **[4 max]**

(b) electron accelerated / mention of centripetal force;
should radiate EM waves/energy;
and spiral into the nucleus; **[3]**

(c) (i) *nuclide*: nucleus characterized by specified number of protons and neutrons/its constituents;

isotope: nuclide with same number of protons / same element <u>and</u> different numbers of nucleons/neutrons; **[2]**

(ii) $^{222}_{86}\text{Rn}$;
$^{4}_{2}\text{He}$ ***or*** $^{0}_{0}\gamma$;
top and bottom numbers balanced correctly; **[3]**

(iii) 6 half-lives occurred;
9600 years; **[2]**

Part 2 Waves

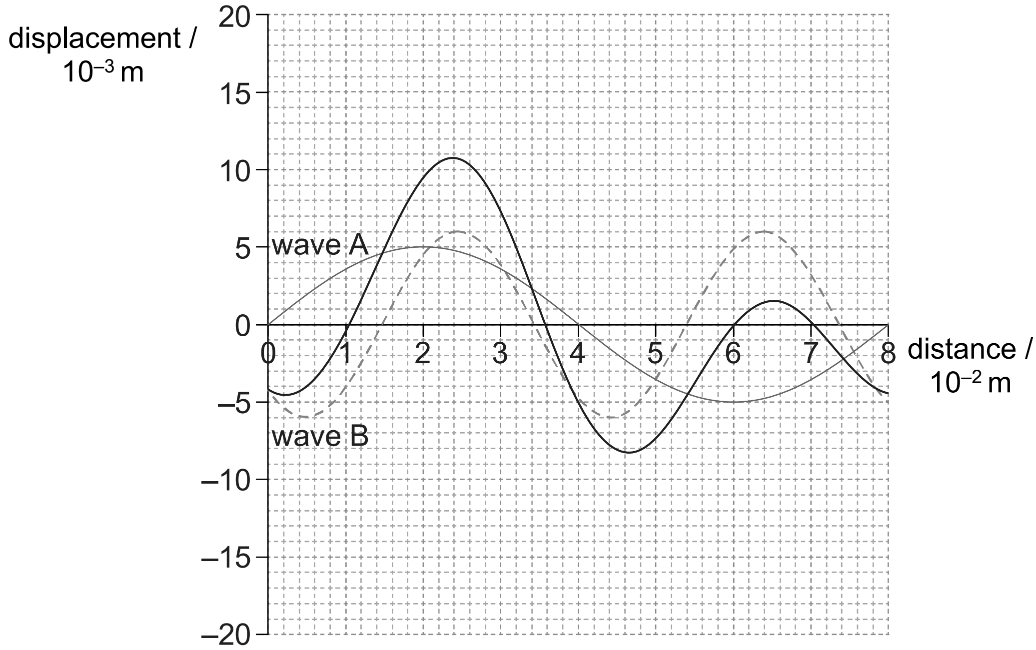
(d) 5 mm ***or*** 5.0 mm; *units are required* **[1]**
Allow other units, eg: $5/5.0\times10^{-3}$ *m.*

(e) (i) wavelength = 8.0 cm ***or*** 8 cm; *(accept clear substitution in MP2 for this mark)*
$v=(f\lambda=)\,9\times8=72\ \text{cm s}^{-1}$; *units are required* **[2]**

(ii) wavelength = 3.9 cm; *(accept answers in the range of 3.8 to 4.0 cm)*
frequency $=\left(\dfrac{72}{3.9}=\right)18$;
Hz ***or*** s^{-1}; **[3]**

(f) (i) when two or more waves (of the same nature) meet/interfere / *OWTTE*;
the resultant displacement is the (vector) sum of their individual displacements; *(do not allow constructive or destructive interference as answer to this point)* **[2]**
Do not accept "amplitude" for "displacement" anywhere in answer.

(ii)



start and end points correct (equal B) and crossing points on distance axis correct (1, 3.6, 6, 7);
peaks and troughs at (2.4, 11) (4.6, –8) (6.5, 1.5);
general shape correct as in example; *(maximum and minimum must be alternating +/–)* **[3]**

5. **Part 1** Energy resources

(a) pump storage;
renewable as can be replaced in short time scale / storage water can be pumped back up to fall again / source will not run out; **[2]**

(b) (i) (allows coolant to) transfer thermal/heat (energy) from the reactor/(nuclear) reaction to the water/steam; **[1]**
Must see reference to transfer.

(ii) reduces speed/kinetic energy of neutrons; *(do not allow "particles")*
improves likelihood of fission occurring/U-235 capturing neutrons; **[2]**

(c) (i) (203 MeV is equivalent to) 3.25×10^{-11} J;
6.02×10^{23} nuclei have a mass of 235 g / evaluates number of nuclei;
(2.56×10^{21} nuclei produce) 8.32×10^{10} J / multiplies two previous answers; **[3]**

(ii) 2.97×10^{6} ***or*** 3.0×10^{6}; *(allow ECF from (c)(i))* **[1]**

(iii) *fossil fuel station*:
large transportation cost;

nuclear station:
needs to be isolated (from human settlement) for safety / needs to be near water source; **[2]**

(d) (i) water flows between water masses/reservoirs at different levels;
flow of water drives turbine/generator to produce electricity;
at off peak times the electricity produced is used to raise water from lower to higher reservoir; **[3]**

(ii) use of $\frac{mgh}{t}$;

$\frac{m}{t} = \frac{4.5 \times 10^{6}}{0.92 \times 9.81 \times 57}$;

8.7×10^{3} kg s^{-1}; **[3]**

Part 2 Thermal physics

(e) specific heat capacity is/refers to energy required to change the temperature (without changing state);
specific latent heat is energy required to change the state/phase without changing the temperature; **[2]**
If definitions are given they must include salient points given above.

(f) (i) gravitational potential energy $\rightarrow$ kinetic energy;
kinetic energy $\rightarrow$ internal energy/thermal energy/heat energy; **[2]**
Do not allow "heat".
Two separate energy changes must be explicit.

(ii) use of $mc\Delta T$;
use of $n \times mg\Delta h$;
equating $(c\Delta T = ng\Delta h)$;
236 ***or*** 240;

or

use of $\Delta U = mc\Delta T$;
$(0.22 \times 1.3 \times 10^2 \times 8 =)$ 229 J;
$n \times mg\Delta h = 229$ J;
$n = \dfrac{229}{0.22 \times 9.81 \times 0.45} = 236$ ***or*** 240; *(allow if answer is rounded up to give complete number of inversions)* **[4]**

6. Part 1 Kinematics and Newton's laws of motion.

(a) (i) distances itemized; *(meaning must be clear)*
distances equated;
$t = \frac{2v}{a}$ / cancel and re-arrange;
substitution $\left(\frac{2 \times 45}{3.2}\right)$ shown / 28.1s seen; **[4]**

or

clear written statement that the average speed of B must be the same as constant speed of I;
as B starts from rest the final speed must be 2×45;
so $t = \frac{\Delta v}{a} = \frac{90}{3.2}$;
28.1 s seen; *(for this alternative the method must be clearly described)*

or

attempts to compare distance travelled by I and B for 28 s;
I distance $= (45 \times 28 =)\ 1260$ m;
B distance $= (\frac{1}{2} \times 3.2 \times 28^2 =)\ 1255$ m;
deduces that overtake must occur about $\left(\frac{5}{45} =\right) 0.1$ s later;

(ii) use of appropriate equation of motion;
$(1.26 \approx)\ 1.3$ km; **[2]**

(b) driver I moves at constant speed so no net (extra) force according to Newton 1;
driver B decelerating so (extra) force (to rear of car) (according to Newton 1) / momentum/inertia change so (extra) force must be present;
(hence) greater tension in belt B than belt I; **[3]**
*Award **[0]** for stating that tension is less in the decelerating car (B).*

(c) (i) $930 \times v + 850 \times 45 = 1780 \times 52$ ***or*** statement that momentum is conserved;
$v = 58$ m s^{-1}; **[2]**

(ii) use of force $= \frac{\text{change of momentum}}{\text{time}}$ (or any variant, *eg*: $\frac{930 \times 6.4}{0.45}$);
13.2×10^3 N; *(must see matched units and value ie: 13 200 without unit gains MP2, 13.2 does not)* **[2]**
Allow use of 58 m s^{-1} from (c)(i) to give 12 400 N.

Part 2 Electrical circuits

(d) ammeter must have very low resistance/much smaller than *R*;
voltmeter must have very large resistance/much larger than *R*; **[2]**
*Allow **[1 max]** for zero and infinite resistance for ammeter and voltmeter respectively.*

(e) power (loss in resistor) $= 0.36$ W;
$I^2 \times 0.80 = 0.36$;
$I = 0.67$ A ***or*** $\sqrt{\left(\frac{0.36}{0.8}\right)}$; **[3]**

(f) (i) resistance of the components/chemicals/materials within the cell itself; *(not "resistance of cell")*
leading to energy/power loss in the cell; **[2]**

(ii) power (in cell with 0.7 A) $= 0.58$ W;
$0.7^2 \times r = 0.58$;
$r = 1.2\,\Omega$; **[3]**

or

when powers are equal;
$I^2R = I^2r$;
so $r = R$ which occurs at $1.2(5)\,\Omega$;
*Award **[1 max]** for bald 1.2(5) Ω.*

(g) $(E = I(R + r)) = 0.7(0.8 + 1.2)$;
1.4 V; **[2]**
Allow ECF from (e) or (f)(ii).

or

when $R = 0$, power loss $= 1.55$;
$E = (\sqrt{1.55 \times 1.2} =)\, 1.4$ V;