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 <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.

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 $T \times 10^{-4}$ 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*** $= 7.4 \times 10^{-2}$ ***or*** 7.4 %;
$K = 5.8/5.76/6 \times 10^{-6}$;
$\Delta K = 4 \times 10^{-7}\ \text{m K}^{-3}$ ***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;
$v = \left(\frac{2\pi r}{T} = \right) \frac{2\pi \times 9.4 \times 10^6}{7.7 \times 3600}$ ***or*** $2.1(3) \times 10^3\ \text{m s}^{-1}$; **[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*** $F_c = F_G$;
$M = \frac{v^2 r}{G}$ ***or*** $\frac{(2.13 \times 10^3)^2 \times 9.4 \times 10^6}{6.67 \times 10^{-11}}$;
$M = 6.4 \times 10^{23}$ 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.

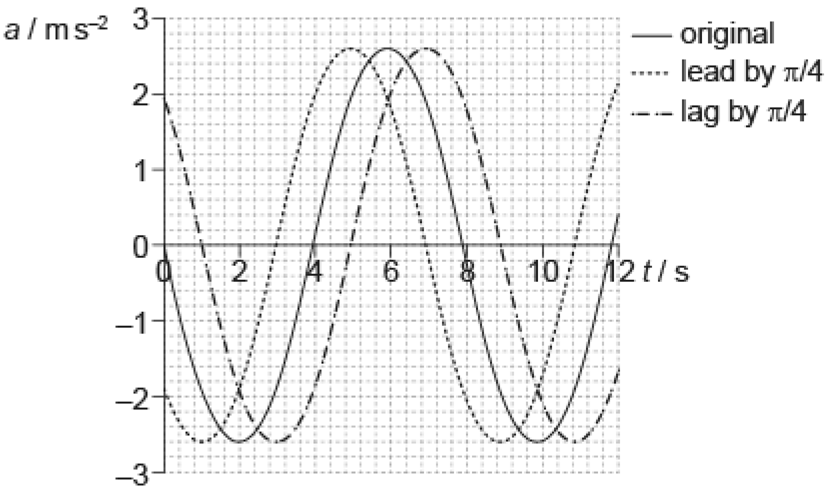
(b) 0.73 N; **[1]**

(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

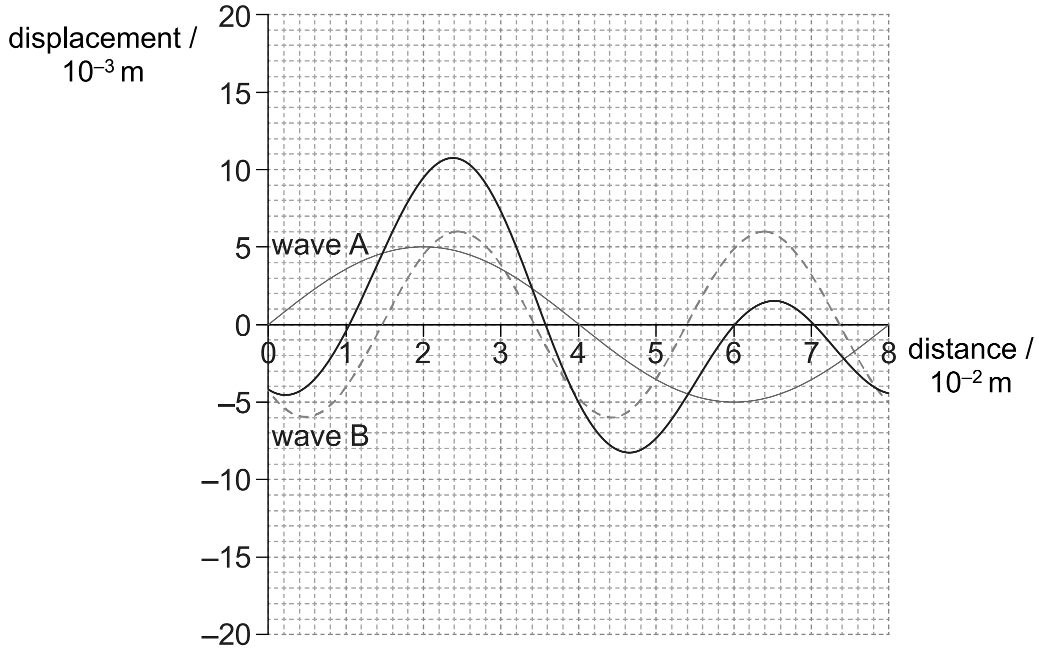
(d) 5 mm ***or*** 5.0 mm; *units are required* **[1]**
Allow other units, eg: $5/5.0\times10^{-3}$ *m*.

(e) (i) wavelength = 8.0 cm ***or*** 8 cm; *(accept clear substitution in MP2 for this mark)*
$v=(f\lambda=)\,9\times8=72$ 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 $=\left(\frac{72}{3.9}=\right)18$;
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 $\frac{mgh}{t}$;
$\frac{m}{t}=\frac{4.5\times10^{6}}{0.92\times9.81\times57}$;
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;
$n = \frac{229}{0.22 \times 9.81 \times 0.45} = 236$ ***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;
$v = 58\text{ m s}^{-1}$; **[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) Ω;
*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;