International Baccalaureate®
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MARKSCHEME

May 2012

PHYSICS

Higher Level

Paper 2

21 pages

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through Scoris™, by e-mail or telephone – if through Scoris™ or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through Scoris™ or by e-mail at any time if they have any problems/queries during the marking process.

If you have any queries on **administration** please contact:

Barry Evans
Subject Operations
IB Assessment Centre
Peterson House
Malthouse Avenue
Cardiff Gate
Cardiff CF23 8GL
GREAT BRITAIN

Tel: +(44) 29 2054 7777

Fax: +(44) 29 2054 7778

E-mail: barry.evans@ibo.org

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 Scoris™ 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, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a part question is worth no marks because the candidate has not attempted the part question, enter an “NR” in the mark panel on the right-hand side of the screen.

7. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. Scoris™ 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 page that contains no other annotation.

9. 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 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. Do **not** award more than the maximum marks allowed for part of a question.

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.

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) any straight line that goes through all error bars; ***[1]***

(ii) line does not go through origin / (0,0) / zero; ***[1]***

(b) (i) $\pm 0.35\ \text{s}^2$; *(accept answers in range 0.3 to 0.4)* ***[1]***

(ii) $\dfrac{\Delta(t^2)}{t^2} = 2\dfrac{\Delta t}{t}$;

$\Delta(t^2) = 0.8^2 \times 2 \times \dfrac{0.1}{0.8}$;

$\Delta(t^2) = 0.16 \approx 0.2\,\text{s}^2$;

answer given to one significant figure;

or

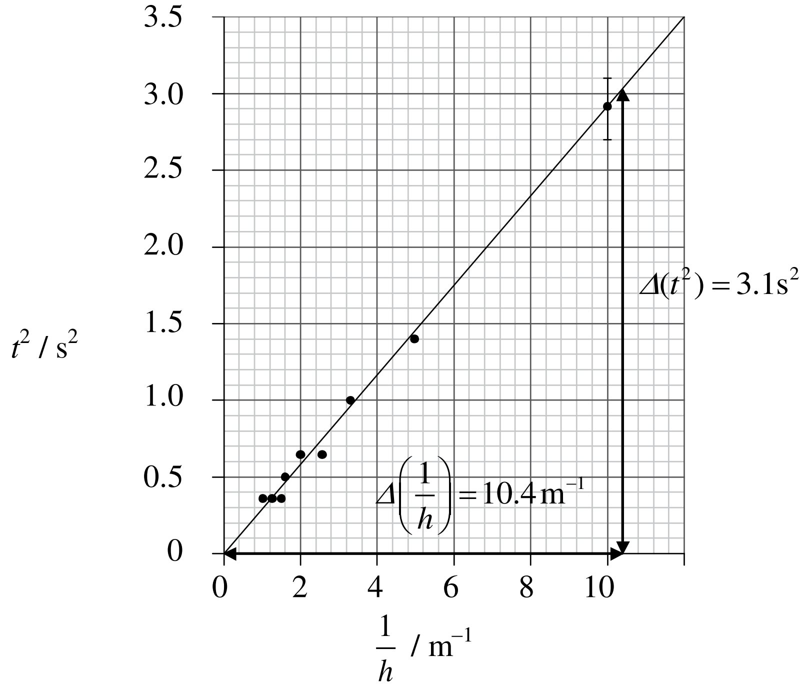
percentage uncertainty in $t = \dfrac{0.1}{0.8} \times 100 = 12.5\%$;

percentage uncertainty in $t^2 = 25\%$;

absolute uncertainty in $t = 0.25 \times 0.8^2 = 0.16 \approx 0.2\,\text{s}^2$;

answer given to one significant figure; ***[4]***

(iii)



use of gradient triangle over at least half of line;
value of gradient = 0.30; *(accept answers in range 0.28 to 0.32)*
= k^2 to give k = 0.55; *(accept answers in range 0.53 to 0.57)*

or

equation of line is $t^2 = \frac{k^2}{h}$;
data values for a point on the line selected;
values substituted into equation to get k = 0.55; *(accept answers in range 0.53 to 0.57)* ***[3]***
*Award **[2]** for answers that use a data point not on the best fit line.*

(iv) $m^{\frac{1}{2}}$ s ; ***[1]***

A2. (a) emission of (alpha/beta/gamma) particles/photons/electromagnetic radiation;
nucleus becomes more (energetically) stable;
constant probability of decay (per unit time);
is random process;
activity/number of unstable nuclei in sample reduces by half over constant time intervals/exponentially;
not affected by temperature/environment / is spontaneous process; ***[3 max]***

(b) (i) 93; ***[1]***

(ii) mass of products is less than mass of reactants / there is a mass defect;
mass is converted into energy (according to equation $E = mc^2$); ***[2]***

(iii) the (minimum) energy required to (completely) separate the nucleons in a nucleus / the energy released when a nucleus is assembled from its constituent nucleons; ***[1]***

(iv) calculation of binding energies as shown below;
americium-241 = 241 × 7.54 = 1817.14 MeV
neptunium-237 = 237 × 7.58 = 1796.46 MeV
helium-4 = 4 × 7.07 = 28.28 MeV
energy released is the difference of binding energies;
and so equals 7.60 MeV; ***[3]***
*Award **[2 max]** for an answer that multiplies by the number of neutrons or number of protons.*
Ignore any negative sign in answer.

A3. (a) the energy required to change the temperature (of a substance) by 1K/°C/unit degree;
of mass 1 kg / per unit mass; ***[2]***

(b) (i) use of $mc\Delta T$;
$0.58 \times c \times [180 - 44] = 0.35 \times 4200 \times [44 - 20]$;
$c = 447\,\text{J kg}^{-1}\,\text{K}^{-1} \approx 450\,\text{J kg}^{-1}\,\text{K}^{-1}$; ***[3]***

(ii) energy would be given off to surroundings/environment / energy would be absorbed by container / energy would be given off through vaporization of water;
hence final temperature would be less;
hence measured value of (specific) heat capacity (of iron) would be higher; ***[2 max]***

A4. (a) (i) $f' = \left(f\left[\dfrac{v}{v-u_s}\right] = \right) 100 \times \left[\dfrac{330}{330-120}\right]$;

$f' = 157\,\text{Hz}$; *[2]*

(ii) $f' = \left(f\left[\dfrac{v+u_o}{v}\right] = \right) 100 \times \left[\dfrac{330+120}{330}\right]$;

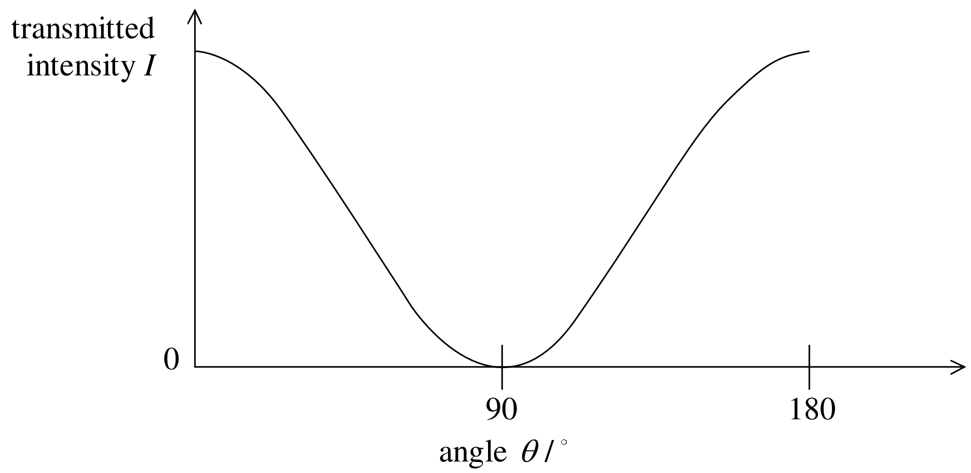
$f' = 136\,\text{Hz}$; *[2]*

(b)

	Measured wavelength	Measured wavespeed
Moving source	less than λ_0	equal to v_0;
Moving observer	equal to λ_0;	greater than v_0;

[3]

A5. (a) general $\cos^2$ shape;
zero intensity at 90˚ and maximum at both 0˚ and 180˚; *[2]*



(b) solution placed between two crossed polarizer;
plane of polarization rotated by an amount that depends on concentration;
rotation of second polarizer/intensity of transmitted light is a measure of concentration;

or

solution placed between two polarizers (at any orientation);
second polarizer rotated until light intensity reaches zero/maximum;
rotation of second polarizer is a measure of concentration; *[3]*

A6. (a) induced emf/induced current acts so as to oppose the change causing it; *[1]*

(b) ball Q enters/leaves magnetic field / experiences changing flux;
so an emf/current is induced;
this causes a magnetic field;
which opposes the motion of / exerts an upward force on ball Q;

or in terms of energy:
ball Q moves through a magnetic field / experiences changing flux;
so an emf/current is induced;
current causes dissipative heating due to resistance;
some kinetic energy changes to thermal energy; *[4]*

SECTION B

B1. Part 1 Wind power

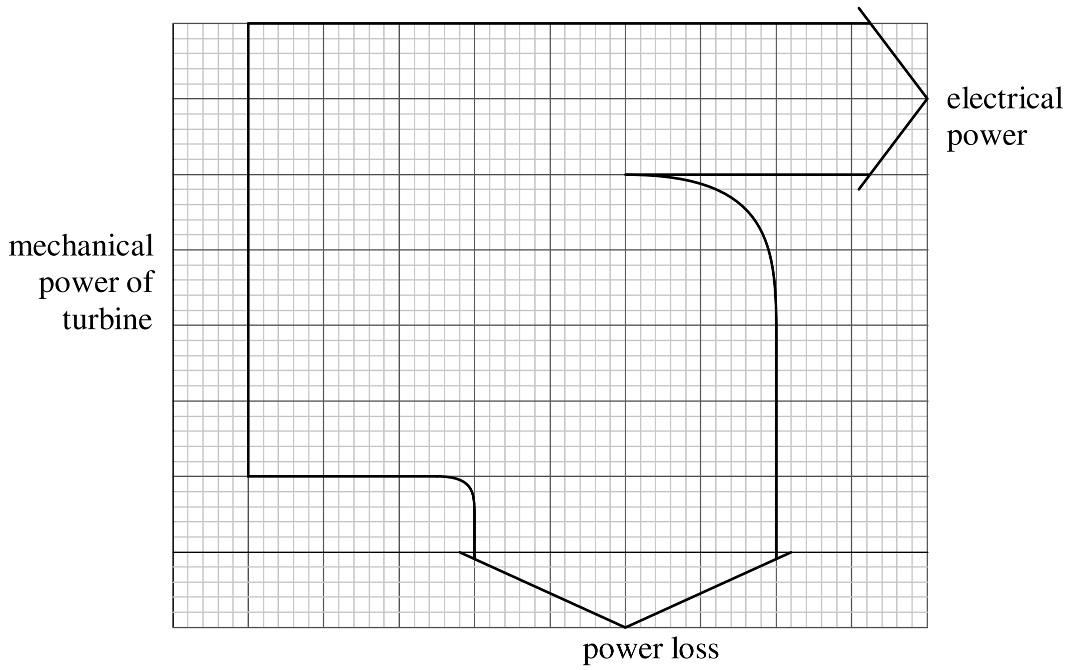
(a) <u>kinetic</u> energy of wind transferred to (rotational) kinetic energy of turbine/blades;
kinetic energy changed to electrical energy in generator/dynamo; ***[2]***
Generator/dynamo must be mentioned.

(b) (i) volume of cylinder of air passing through blades per second $= v\pi r^2$;
mass of air incident per second $= \rho v \pi r^2$;
kinetic energy per second $= \frac{1}{2}mv^2$;
leading to $\frac{1}{2}\pi\rho r^2 v^3$ ***[3]***
*Award **[3]** for answers that combine one or more steps.*

(ii) the speed of the air/wind cannot drop to zero;
wind turbulence / frictional losses in turbine/any moving part / resistive heating in wires; ***[2]***

(c) kinetic energy per second of air entering turbine $= \frac{1}{2}\pi \times 1.1 \times 25^2 \times 9.8^3 = 1.016 \times 10^6$;
kinetic energy per second of air leaving turbine $= \frac{1}{2}\pi \times 2.2 \times 25^2 \times 4.6^3 = 2.102 \times 10^5$;
power extracted $= 1.0 \times 10^6 - 2.1 \times 10^5 = 8.062 \times 10^5 \approx 8.1 \times 10^5$ W; ***[3]***

(d)



correct shape of diagram (allow multiple arrows if power loss split into different components);
relative width of arrows correct;
labels correct; *[3]*

(e) *Advantage*:
wind is renewable so no resources used up / wind is free / no chemical pollution / no carbon dioxide emission / does not contribute to greenhouse effect / is "scalable" *i.e.* many sizes of turbine possible;

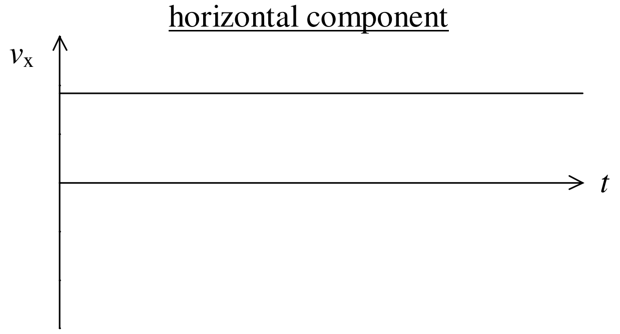
Disadvantage:
expensive initial cost / large land area needed / wind not constant / effect on movement of birds / aesthetically unpleasant / noise pollution / high maintenance costs / best locations far from population centres / low energy density; *[2]*

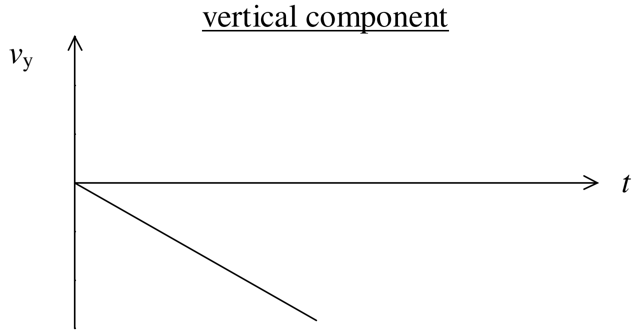
Accept any other suitable advantage or disadvantage.

Part 2 Projectile motion

(a) (i) zero; ***[1]***

(ii) horizontal: any horizontal line not on t-axis (*accept lines above or below t-axis*);
vertical: any diagonal line starting at origin (*accept positive or negative gradients*); ***[2]***

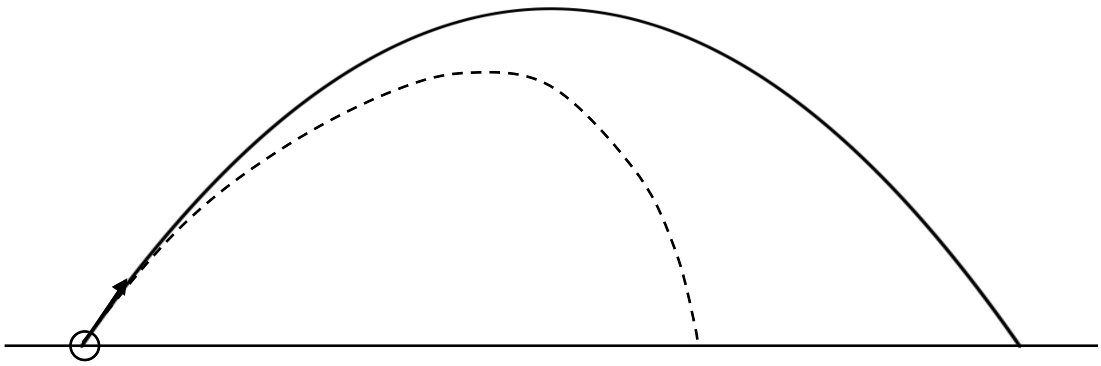




(b) (i) $s_y = \frac{1}{2}a_y t^2 \Rightarrow 110 = \frac{1}{2} \times 10 \times t^2$;
$t = 4.690 \approx 4.7\,\text{s}$; ***[2]***

(ii) $s_x = u_x t = 5.0 \times 4.690$;
$s_x = 23\,\text{m}$; ***[2]***

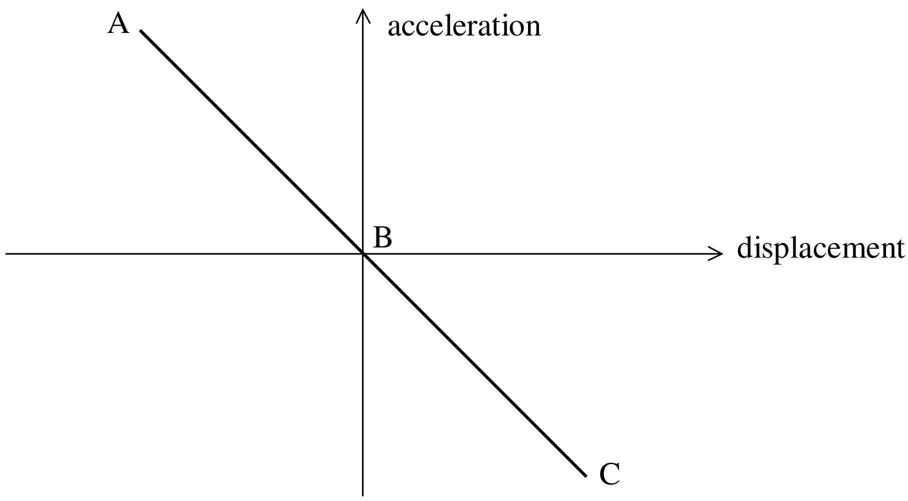
(c) lower maximum height;
lower horizontal range;
asymmetrical with horizontal range before maximum height more than horizontal range after maximum height; ***[3]***



B2. Part 1 Simple harmonic motion and the superposition of waves

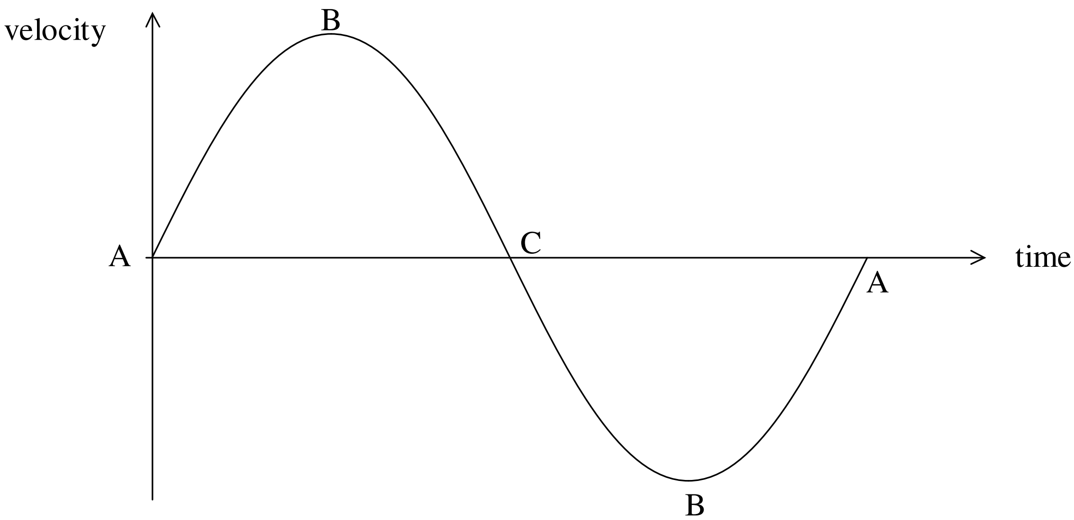
(a) the force/acceleration is proportional to the displacement from the equilibrium position/centre;
the force/acceleration is directed towards the equilibrium position/centre / the force/acceleration is in the opposite direction to the displacement; *[2]*

(b) (i) straight line through the origin;
with negative gradient; *[2]*



(ii) all three labels correct; *[1]*

(c) (i) positive sine graph;
drawn correctly for one period; *[2]*

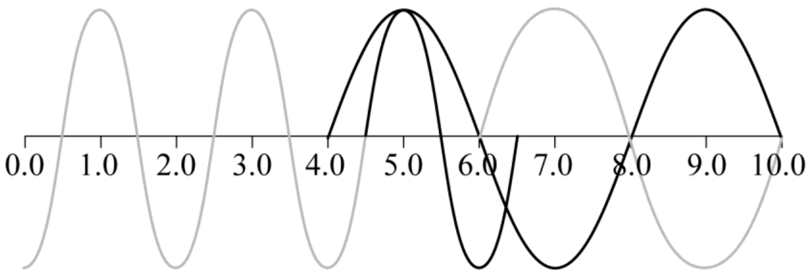


(ii) all three labels correct; *[1]*
Accept either of the As and either of the Bs.
Accept either B if shown on the time axis in the correct position.

(d) $\omega = \frac{2\pi}{T} = \frac{2\pi}{0.20} = 31.42 \approx 31\,\text{rad}\,\text{s}^{-1}$;
$v_{\max} = \omega x_0 = 31.42 \times 0.040$;
$v_{\max} = 1.257 \approx 1.3\,\text{m}\,\text{s}^{-1}$; *[3]*

(e) (i) if two or more waves overlap/meet/pass through the same point;
the resultant displacement at any point is found by adding the displacements produced by each individual wave; *[2]*

(ii) 0.20 s later, wave X will have crests at 5.0, 3.0 and 1.0 m, wave Y will have crests at 5.0 and 9.0 m / each wave will have moved forward by 2.0 m in 0.20 s / wave profiles for 0.20 s later drawn on diagram;



maximum displacement where two crests meet, *i.e.* at 5.0 m; *[2]*

Part 2 Thermodynamics

(a) process *AB*: isobaric;
process *BC*: isochoric / isovolumetric;
process *CA*: isothermal; ***[3]***

(b) use of $\frac{V_2}{V_1} = \frac{T_2}{T_1}$;
to give 750 K; ***[2]***

(c) $W = (P\Delta V = 9\times10^5 \times[5-2]\times10^{-3} =)\,2700$;
$Q = \Delta U + W = 4100 + 2700 = 6800\,\text{J}$; ***[2]***

(d) (i) same number of molecules occupy smaller volume, so disorder and hence entropy decrease; ***[1]***

(ii) heat flows from gas to surroundings, so temperature of surroundings increases, so entropy increases; ***[1]***

(iii) from second law, entropy of universe increases during any process; ***[1]***

*Award **[0]** for simple statement of entropy increases/decreases.*

B3. Part 1 A collision

(a) distance between surfaces of blocks $= 0.900 - 0.050 = 0.850\,\text{m}$;
relative speed between blocks = 0.36 m s^{-1};
$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{0.850}{0.36} = 2.4\,\text{s}$;

or

blocks moving at same speed so meet at mid-point;
distance travelled by block $= 0.450 - 0.025 = 0.425\,\text{m}$;
$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{0.425}{0.18} = 2.4\,\text{s}$; ***[3]***
Award ***[2 max]*** *if distance of 0.90 m or 0.45 m used to get 2.5 s.*

(b) (i) the collision is inelastic;
because kinetic energy is not conserved (although momentum is); ***[2]***

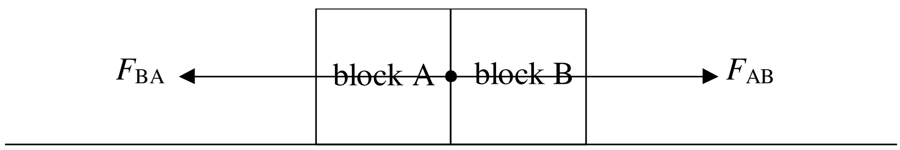
(ii) initial $E_K = \frac{1}{2} \times 0.17 \times 0.18^2 = 0.002754\,\text{J}$;
final $E_K = 0.80 \times 0.002754 = 0.0022032\,\text{J}$;
final speed $= \sqrt{\frac{2 \times 0.0022032}{0.17}}$;
$= 0.16\,\text{m s}^{-1}$

or

$0.8 \times \text{initial } E_K = \text{final } E_K$;
$0.8 \times \frac{1}{2} \times 0.17 \times 0.18^2 = \frac{1}{2} \times 0.17 \times v^2$;
$v = \sqrt{0.8 \times 0.18^2}$;
$= 0.16\,\text{m s}^{-1}$ ***[3]***

(c) (i) if object A exerts a force on object B, then object B (simultaneously) exerts an equal and opposite force on object A / every action has an equal and opposite reaction / *OWTTE*; ***[1]***

(ii) arrows of equal length; *(judge by eye)*
acting through centre of blocks;
correct labelling consistent with correct direction; ***[3]***



(iii) $\Delta v = 0.16 - (-0.18) = 0.34\,\text{m s}^{-1}$;

$a = \frac{\Delta v}{\Delta t} = \frac{0.34}{0.070} = 4.857\,\text{m s}^{-2}$;

$F = ma = 0.17 \times 4.857 = 0.83\,\text{N}$;

or

$\Delta v = 0.16 - (-0.18) = 0.34\,\text{m s}^{-1}$;

$\text{impulse} = F\Delta t = m\Delta v \Rightarrow F = \frac{0.17 \times 0.34}{0.07}$;

$F = 0.83\,\text{N}$ ***[3]***

Part 2 Digital data storage

(a) analogue: any continuous variable line, not going backwards in time;
digital: any signal with discrete values/two states only; ***[2]***

(b) left-most digit;
is associated with the highest power of 2 (so has the biggest effect on the number); ***[2]***

(c) (i) (information is) encoded (onto a spiral track) as a series of flats/pits and bumps/lands;
(transitions between) which correspond to binary 0 and 1; ***[2]***

(ii) DVDs use a laser of shorter wavelength;
hence bumps/pits/flats/lands can be spaced closer together;
spiral can be tighter; ***[2 max]***

(iii) wavelength in coating $= \frac{630}{1.53} = 412$;

pit depth $= \left(\frac{\lambda}{4} = \right) 103\,\text{nm}$; ***[2]***

B4. Part 1 Gravitational fields

(a) there is an <u>attractive</u> force;
between any two point/small masses;
proportional to the product of their masses;
and inversely proportional to the square of their separation; ***[3 max]***
Accept formula with all terms defined.

(b) use of $g = \frac{F}{m}$ and $F = \frac{GmM}{R^2}$;
evidence of substitution/manipulation;
to get $g = \frac{GM}{R^2}$ ***[2]***

(c) $$\frac{g_M}{g_E} = \frac{\frac{M_M}{R_M^2}}{\frac{M_E}{R_E^2}} \Rightarrow \frac{M_M}{M_E} = \frac{g_M}{g_E} \times \left[\frac{R_M}{R_E}\right]^2;$$

$M_M (= 0.38 \times 0.53^2 M_E) = 0.11 M_E$; ***[2]***

Part 2 Electric current and resistance

(a) (i) $\frac{\text{potential difference across the component}}{\text{current in the component}}$; *[1]*

*Award **[0]** for simple statement of voltage divided by current.*

(ii) Ohm's law states that voltage is (directly) proportional to current **or** $\frac{\text{potential difference}}{\text{current}}$/resistance is a constant;

graph not linear/gradient not constant so Ohm's law not obeyed / calculation of $\frac{V}{I}$ at two points showing that they are different; *[2]*

*Award **[0]** for bald statement of Ohm's law not obeyed.*

(b) (from graph, when $V = 2.8$ V,) $I = 0.33$ A; *(accept answers in range 0.32 to 0.34 A)*

$R = \frac{V}{I} = \frac{2.8}{0.34} = 8.5\ \Omega$; *(accept answers in range 8.2 to 8.8 Ω)* *[2]*

(c) each lamp has a potential difference of 3.0 V so current equals 0.35 A; *(accept answers in range 0.34 to 0.35 A)*

2.1 W; *(accept answers in range 2.0 to 2.1 W)* *[2]*

*Award **[1]** for answers that use voltage 6.0 V with current 0.52 A to get P = 3.1 W.*

Part 3 Atomic energy levels

(a) all particles have an associated wavelength / *OWTTE*;
wavelength is given by $\lambda = \frac{h}{p}$, where h is Planck's constant and p is momentum; ***[2]***

(b) only certain values of wavelength/frequency observed;
corresponding to electron transitions between specific energy levels / *OWTTE*; ***[2]***

(c) from de Broglie hypothesis, $p_n = \frac{h}{\lambda_n} = \frac{nh}{2L}$;
kinetic energy given by $E_K = \frac{p^2}{2m_e}$;
combined and manipulated to obtain result; ***[3]***

(d) (i) $\lambda = \frac{2L}{n} = \frac{2 \times 1.0 \times 10^{-10}}{1} = 2.0 \times 10^{-10}$;
$p = \frac{h}{\lambda} = \frac{6.6 \times 10^{-34}}{2.0 \times 10^{-10}} = 3.3 \times 10^{-24}\ \text{kg m s}^{-1}$; ***[2]***
*Award **[2]** for alternative methods, e.g. calculating energy then momentum.*

(ii) use of $\Delta x \Delta p \geq \frac{h}{4\pi}$;
to get $\Delta p \geq \frac{6.6 \times 10^{-34}}{4\pi \times 0.5 \times 10^{-10}} = 1.1 \times 10^{-24}\ \text{kg m s}^{-1}$; ***[2]***