

MARKSCHEME

November 2003

PHYSICS

Higher Level

Paper 2

Subject Details: **Physics HL Paper 2 Markscheme**

General

A markscheme often has more specific points worthy of a mark than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

When deciding upon alternative answers by candidates to those given in the markscheme, consider the following points:

- ◆ Each marking point has a separate line and the end is signified by means of a semicolon (;).
- ◆ An alternative answer or wording is indicated in the markscheme by a “/”; either wording can be accepted.
- ◆ Words in () in the markscheme are not necessary to gain the mark.
- ◆ The order of points does not have to be as written (unless stated otherwise).
- ◆ If the candidate’s answer has the same “meaning” or can be clearly interpreted as being the same as that in the markscheme then award the mark.
- ◆ 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 not achieved or what they have got wrong.
- ◆ Occasionally, a part of a question may require a calculation whose answer is required for subsequent parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded.
- ◆ Units should always be given where appropriate. Omission of units should only be penalized once. Ignore this, if marks for units are already specified in the markscheme.
- ◆ Deduct **1 mark in the paper** for gross sig dig error *i.e.* for an **error of 2 or more digits**.

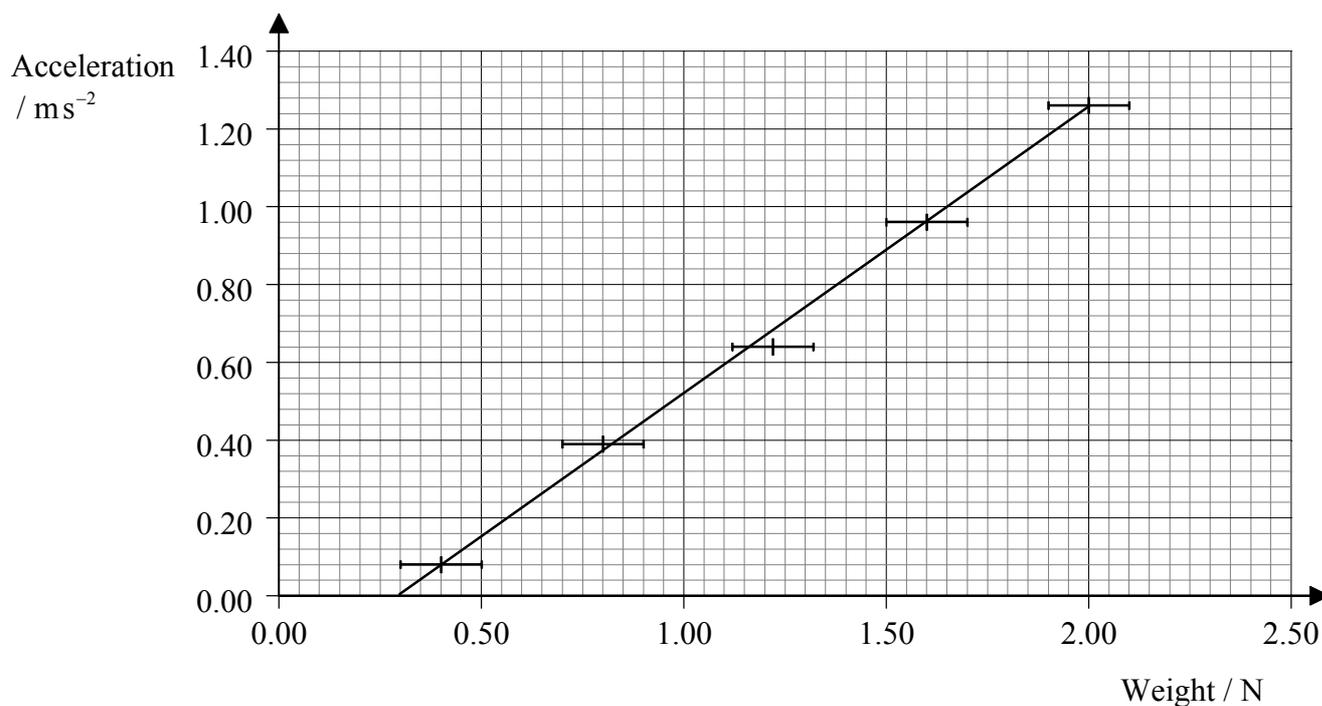
e.g. if the answer is 1.63:

2	<i>reject</i>
1.6	<i>accept</i>
1.63	<i>accept</i>
1.631	<i>accept</i>
1.6314	<i>reject</i>

However, if a question specifically deals with uncertainties and significant digits, and marks for sig digs are already specified in the markscheme, then do **not** deduct again.

SECTION A

- A1.** (a) a straight line;
through the origin; **[2 max]**
- (b) any straight line;
that fits within ALL the error bars; **[2 max]**



- (c) (i) a *systematic* error is when every data point deviates from the “correct” value;
by the same fixed amount as seen by intercept on graph / *OWTTE*; **[2 max]**
Accept answers that explain by giving an example of a possible systematic error
e.g. friction.
- (ii) 0.3 N; **[1]**
Accept 0.25 N → 0.35 N. N.B. Watch for use of wrong axis!
- (iii) realization that mass = (gradient)⁻¹;
Award this mark for full Newton II equation (with friction)
to give mass = 1.4 kg (*Accept 1.2 kg → 1.6 kg.*); **[2 max]**
Use of f = ma for 1 data point receives [0] (unless candidate’s line is through origin)
watch for ecf from candidate’s own line.

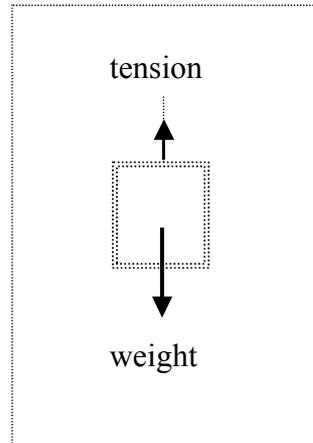
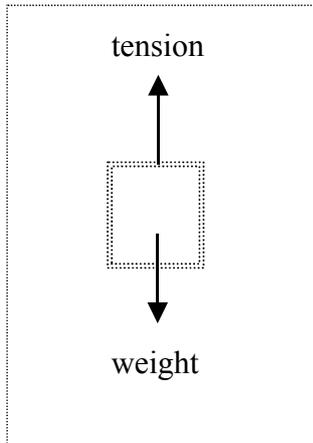
- A2. (a) statement that gravitational mass and inertial mass have the same numerical value;
understanding of what gravitational mass means;
e.g. "a quantity that determines the gravitational force on the object"
understanding of what inertial mass means;
e.g. "a quantity that determines the acceleration of the object"

[3 max]

- (b) *Mark part (i) and (ii) together.*
weight arrow the same in both diagrams;
magnitude of tension (size of arrow) **equal to** weight in (i);
magnitude of tension (size of arrow) **less than** weight in (ii);

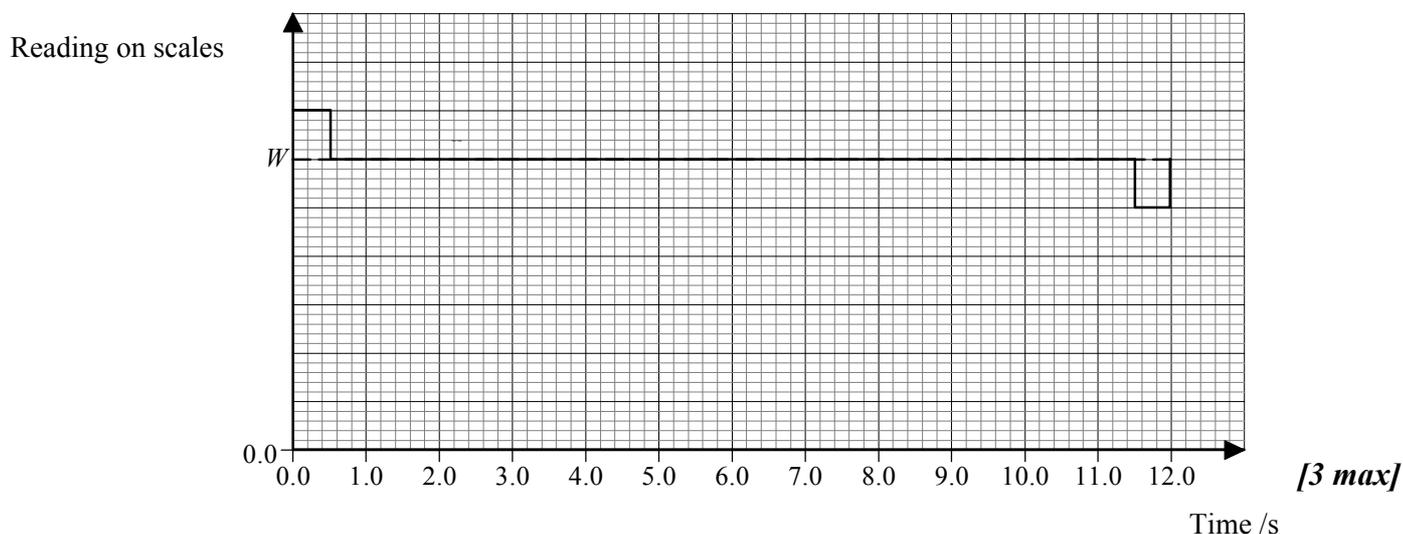
(i) 0.50 to 11.50 s

(ii) 11.50 to 12.00 s



[3 max]

- (c) a constant value **greater** than W from 0.00 to 0.50 s;
 a constant value **equal** to W from 0.50 to 11.50 s;
 a constant value **less** than W from 11.50 to 12.00 s;



- (d) *[1] for each appropriate and valid point. Essentially [2] for journey up and [2] for journey down. Some explanation or justification is required for full marks e.g.*
 the law of conservation of energy does apply to round trip;
 energy is all dissipated into heat and sound;
 on the way up, most electrical energy converted into g.P.E., initially some electrical energy is converted into K.E.;
 on the way down electrical energy does work “breaking” lift some (not all) g.P.E. is converted into K.E.;
- [4 max]**
- Reject answers that imply that P.E. converts into K.E. as lift falls.*

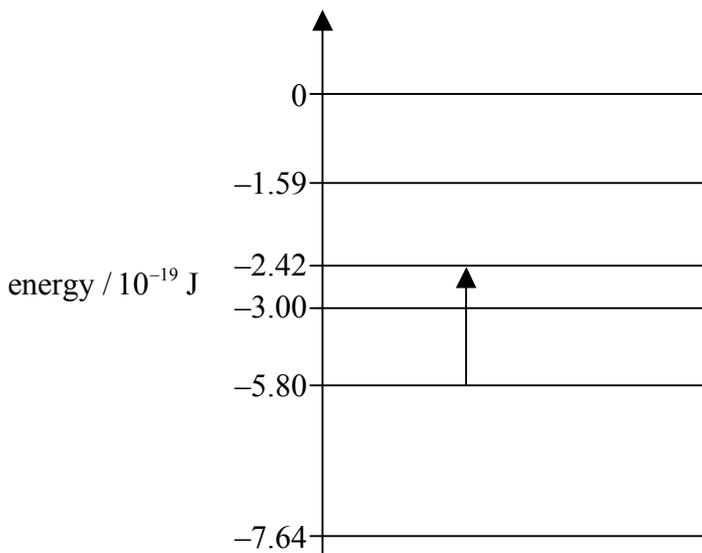
- A3. (a) *[1]* for any valid and relevant point e.g.
 Geiger-Marsden experiment involved bombardment of gold foil by alpha particles;
 most passed straight through / were deviated through small angles, but some deflected
 through large angles;
 these alpha particles were heading towards central nucleus; *[3 max]*
- (b) *[1 max]* for any valid and relevant point e.g.
 protons in nucleus repel each other (seen or implied);
 but are held together by the strong nuclear force / or neutrons are involved keeping it bound
 together / *OWTTE*; *[2 max]*
- (c) attempted use of $F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$;
 with $q_1 = q_2 = 10^{29} e = 1.6 \times 10^{-10} \text{ C}$;
 and $r = 100 \text{ m}$;
 to get $F = 2.3 \times 10^{26} \text{ N} \approx 10^{26} \text{ N}$; *[4 max]*
- (d) substitution into $F = \frac{Gm_1 m_2}{r^2}$
 with $m_1 = m_2 = 70 \text{ kg}$;
Accept any sensible estimate, say 30 kg \rightarrow 110 kg
 and $r = 100 \text{ m}$
 to get $F = 3.3 \times 10^{-11} \text{ N} \approx 3 \times 10^{-11} \text{ N}$;
above range gives $6 \times 10^{-12} \text{ N} \rightarrow 8 \times 10^{-11} \text{ N}$ *[2 max]*
- (e) people are overall electrically neutral / equal numbers of positive charges mean that
 overall the electrical force is zero / *OWTTE*;
 the gravitational force of attraction is too small to notice; *[2 max]*
*N.B. This question is different from Standard Level, and so is markscheme. If marking
 both Higher and Standard Level, you need to take care!*

B1. (a) (i) *Answer to include:*
 missing frequencies / wavelengths;
 in otherwise continuous spectrum; **[2 max]**

(ii) *Answer to include:*
 light from Sun is split into its component wavelengths;
 using prism / grating; **[2 max]**

(b) (i) correct substitution into $E = hf$ and $c = f\lambda$ to give $E = \frac{hc}{\lambda}$;
 $E = 6.63 \times 10^{-34} \times 3 \times 10^8 / 5.88 \times 10^{-7}$;
 $= 3.38 \times 10^{-19} \text{ J}$ **[2 max]**

(ii) transition is an absorption so involves electron be “promoted” up between two levels;
 energy of gap must be exactly $= 3.38 \times 10^{-19} \text{ J}$;
 this is between $(-5.80 \times 10^{-19} \text{ J})$ and $(-2.42 \times 10^{-19} \text{ J})$ levels; **[3 max]**
[2 max] can be given for other relevant information concerning, for example, the
 existence of photons with different energies in sunlight / the immediate re-radiation
 in random directions. The final mark is for identifying the energy levels concerned.
 This can also just be shown on the diagram (see below).



(c) *Mark (i) and (ii) together. [1] for each relevant point e.g.*
 Bohr assumed electrons were in circular orbits around nucleus;
 of fixed angular momentum that;
 were stable (did not radiate) and thus the energy can be calculated;
 Schrödinger considers electron “probability” waves;
 only some standing waves fit the boundary conditions;
 and these fix the available energies for the electron; **[6 max]**
N.B. [4 max] for any one of the models.

(d) a **fusion** reaction;
 since Hydrogen nuclei are joining to create helium / any other relevant further detail / explanation; **[2 max]**

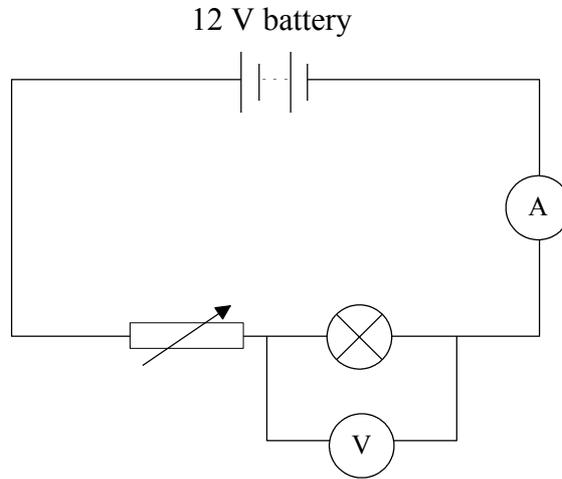
- (e) (i) *atomic number:* 6;
mass number: 12; **[2 max]**
N.B. if 6 and 12 are reversed, **[1 max]**.
- (ii) mass before = $3 \times (6.648325 \times 10^{-27} \text{ kg})$
 $= 1.9944975 \times 10^{-26} \text{ kg}$
 mass of Carbon = $1.9932000 \times 10^{-26} \text{ kg}$
 so mass defect = $1.9944975 \times 10^{-26} - 1.9932000 \times 10^{-26} \text{ kg}$
 $= 0.0012975 \times 10^{-26} \text{ kg};$
 correct substitution into $E = mc^2$;
 energy released = $0.0012975 \times 10^{-26} \times 9.00 \times 10^{16} \text{ J}$
 $= 1.16775 \times 10^{-12} \text{ J}$
 $\approx 1.17 \times 10^{-12} \text{ J};$ **[3 max]**
- (f) (i) an (electron-) antineutrino; **[1]**
Reject "neutrino".
- (ii) idea that there is a fixed total energy of decay;
 total energy shared between the (three) resulting particles / *OWTTE*; **[2 max]**
- (iii) correct calculation of decay constant λ ;
 $\lambda = \ln 2 / 0.82 = 0.845$
 correct substitution into $N = N_0 e^{-\lambda t}$;
 to give $N = N_0 e^{-8.45}$ therefore $\frac{N}{N_0} = e^{-8.45} = 0.000213 = 0.02\%;$ **[3 max]**
N.B. Award attempts without full equation **[1 max]**.
- (iv) an up quark changes into a down quark;
 any other relevant detail; **[2 max]**
*e.g. this involves the weak interaction / statement of quark content of proton (UUD)
 or neutron (UDD).*

B2. Part 1

- (a) (i) attempt at using principle of moments (even if in error);
 $F \times 1.2 = 600 \times 0.4$;
therefore $F = 200 \text{ N}$; **[3 max]**
- (ii) resultant force = zero therefore, reaction = $600 - 200 = 400\text{N}$;
up; **[2 max]**
- (b) (i) correct use of $F_{\text{horizontal}} = 260 \cos 40$ or $260 \sin 50$;
to give $F_{\text{horizontal}} = 199.2 \text{ N} \approx 200 \text{ N}$; **[2 max]**
- (ii) realization that resultant force is zero (constant velocity);
so friction = $F_{\text{horizontal}} \approx 200 \text{ N}$; **[2 max]**

B2. Part 2

- (a) correct positioning of ammeter;
 correct positioning of voltmeter;
 e.g.



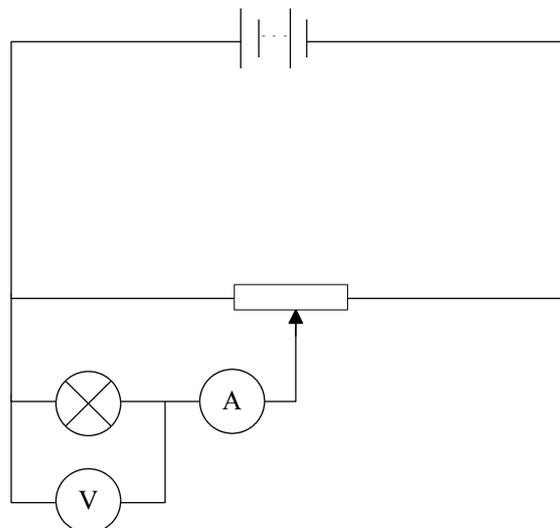
[2 max]

- (b) (i) the battery (**or** the ammeter **or** the wires) must have some resistance;
 some p.d. is “used up” so less “available” / *OWTTE*;
- (ii) low voltage requires low current and thus large resistance;
 max resistance of variable resistor not infinite / *OWTTE*;
- (c) (i) any circuit involving potentiometer or equivalent;
 that correctly controls the p.d. across the bulb;
 with meters still correctly connected;

[2 max]

[2 max]

[3 max]



- (ii) [1] for each relevant point.
 e.g. the 12 V is “shared” by the two halves of the resistor;
 if the LH half is zero resistance, the p.d. will be zero / *OWTTE*;

[2 max]

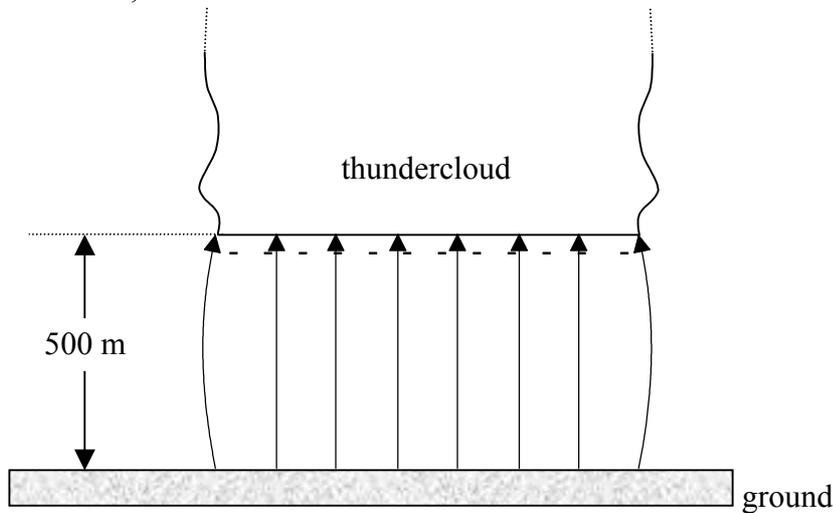
- (d) lamp B must have greater power dissipation;
since it has a greater current for the same p.d. / *OWTTE*;
so power dissipation ($= V \times I$) is greater; **[3 max]**
- (e) (i) current lamp A equals the current in lamp B / *OWTTE*; **[1]**
- (ii) any answer that is less than 0.5 A but above 0.3 A;
realization (seen or implied) that each lamp does not have the same p.d.;
explanation (or evidence from the graph) of trying to find the current when the
individual p.d.s sum to 12 V;
to give 0.4 A (± 0.1); **[4 max]**
- (iii) lamp A will have greater power dissipation;
since current the same, but it takes greater share of p.d.; **[2 max]**

B3. Part 1

- (a) there are two types of charge: positive and negative;
if they are moved apart, this is charge separation / *OWTTE*; **[2 max]**

- (b) electric field strength is the force per unit charge;
felt by a positive test charge placed in the field / *OWTTE*; **[2 max]**
Accept mathematical definitions, but do not award any marks for just copying the formula from the data booklet. Answers need to define the terms to receive credit.

- (c) straight lines from Earth to negative;
equally spaced;
edge effect shown;



[3 max]

- (d) (i) correct substitution to calculate $\sigma (= 2.86 \times 10^{-6} \text{ C m}^{-2})$;
 $E = 20 / (8.85 \times 10^{-12} \times 7 \times 10^6) \text{ V m}^{-1}$;
 $= 3.2 \times 10^5 \text{ V m}^{-1}$;
 $= 3 \times 10^5 \text{ V m}^{-1}$

[3 max]

- (ii) **[1]** for each appropriate and sensible assumption e.g.
edge of cloud parallel to ground;
cloud and ground effectively infinite length;
permittivity of air the same as vacuum;
ground and cloud surface both flat, etc.;

[2 max]

- (e) potential difference $= 3.2 \times 10^5 \times 500 \text{ V}$;
 $= 1.6 \times 10^8 \text{ V}$;

[2 max]

Accept $1.5 \times 10^8 \text{ V}$.

- (f) (i) average current $= 20 \text{ C} / 20 \text{ ms}$
 $= 1000 \text{ A}$;

[1]

- (ii) average p.d. $= 1.6 \times 10^8 \text{ V} / 2 = 0.8 \times 10^8 \text{ V}$;
energy released $= \text{average p.d} \times \text{charge} = 0.8 \times 10^8 \times 20$;
 $= 1.6 \times 10^9 \text{ J}$;

[3 max]

[2] if maximum p.d. used to get $3.2 \times 10^9 \text{ J}$.

B3. Part 2

- (a) Q is destructive interference;
 since the difference in path lengths from the speakers to Q;
 must be a $\frac{1}{2} \lambda$ difference;
Accept $(n + \frac{1}{2})$ difference / OWTTE.

[3 max]

- (b) frequency = 2 Hz \Rightarrow time between loud points = 0.5 s;
 wavelength of sound, $\lambda = 330 / 360 = 0.917$ m;
 distance between loud points = $\lambda D / a$;
 $= (0.917 \times 10.0 / 4.0)$ m
 $= 2.29$ m;

Accept solutions using $n\lambda = d \sin \theta$.

since $\text{speed} = \text{distance} / \text{time};$
 $= 2.29 / 0.5 \text{ ms}^{-1}$
 $= 4.58 \text{ ms}^{-1}$
 $\approx 5 \text{ ms}^{-1};$

[6 max]

N.B. *The solution above is, of course, an estimation. If the answer attempts “full” solution (i.e. does not resort to small angle estimations) but still gets confused with maths, full marks can be awarded if appropriate progress is made or understanding shown.*

- (c) realization that the set-up is to do with beats;
 two signal generators give different frequencies that are 2 Hz apart;
 must be 359 Hz and the other 361 Hz;

[3 max]

B4. Part 2

- (a) statement (implication) that work done is associated with area within the rectangle;
Do not award mark for just "area" without reference.
 calculation of $2 \times 10^5 \times 8 = 1.6 \times 10^6 \text{ J}$;

[2 max]

- (b) thermal energy from hot reservoir = $1.8 \times 10^6 + 1.6 \times 10^6 \text{ J}$
 = $3.4 \times 10^6 \text{ J}$;

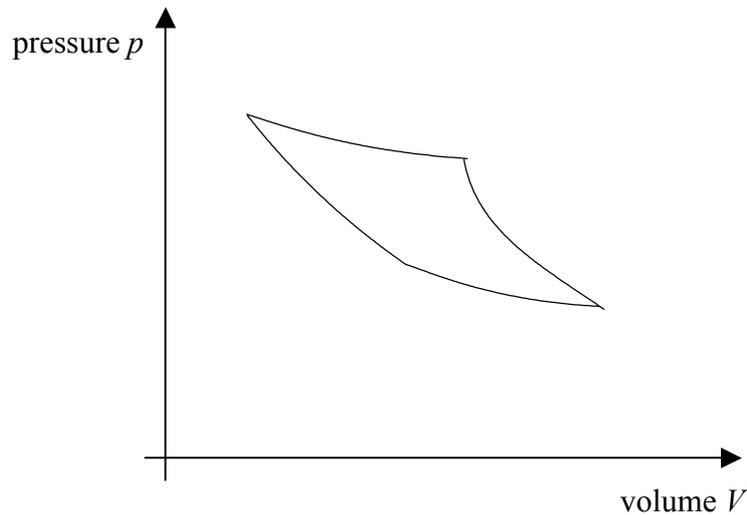
efficiency = work done / thermal energy from hot reservoir
 = $1.6 \times 10^6 / 3.4 \times 10^6$
 = 47 %;

[2 max]

[0] for $1.6 \times 10^6 / 1.8 \times 10^6 = 89 \%$.

- (c) closed cycle of rough approximate shape;
 quality of diagram (adiabatic "steeper" than isothermal *etc.*);

[2 max]



- (d) (i) adiabatic (expansion and contraction);
 isothermal (expansion and contraction);

[2 max]

- (ii) correct "sense" of adiabatic followed by and isothermal *etc.*;
e.g. adiabatic (expansion) then
 isothermal (contraction) then
 adiabatic (contraction) then
 isothermal (expansion) then

correct identification of adiabatic as the steeper curve when compared with isothermal; [2 max]