Suggested Solutions

<table>
<tr><th>No.</th><th>Solution</th><th>Remark</th></tr>
<tr><td>1(a)</td><td>R = 68 Ω

I = 121.1 mA

y = 41.2 cm</td><td>[1]
- for correct d.p and unit in I and y</td></tr>
<tr><td>1(b)</td><td>
<table>
<tr><th>R/Ω</th><th>y/cm</th><th>I/mA</th><th>$\frac{R}{y}$ / Ω m^{-1}</th><th>IR/V</th></tr>
<tr><td>56</td><td>42.5</td><td>121.1</td><td>130</td><td>6.8</td></tr>
<tr><td>68</td><td>41.2</td><td>121.1</td><td>170</td><td>8.2</td></tr>
<tr><td>82</td><td>40.0</td><td>121.0</td><td>210</td><td>9.9</td></tr>
<tr><td>100</td><td>38.5</td><td>121.0</td><td>260</td><td>12.1</td></tr>
<tr><td>120</td><td>37.7</td><td>121.2</td><td>318</td><td>14.5</td></tr>
</table>
</td><td>[1]
- headings and units
- 5 sets of data

[1]
- d.p. of raw data
- s.f. of processed data

[1] correct calculation, allow 1 slip</td></tr>
<tr><td>1(c)</td><td>Refer to attached graph.</td><td>[1] axes: units, scale

[1] plotted points accurate to half of smallest division

[1] best fit line</td></tr>
<tr><td>1(c)</td><td>Given $\frac{R}{y} = \frac{QIR}{F} - Q$
Graph of $\frac{R}{y}$ vs IR is plotted, where $\frac{Q}{F}$ is the gradient and $-Q$ is the y-intercept.

Gradient$= \frac{305 - 137.5}{14.0 - 7.0} = 23.9$
$\Rightarrow \frac{Q}{F} = 23.9$
Substitute $(14.0, 305)$ into the equation,
$305 = (23.9)(14.0) + (-Q)$
$Q = 29.6$

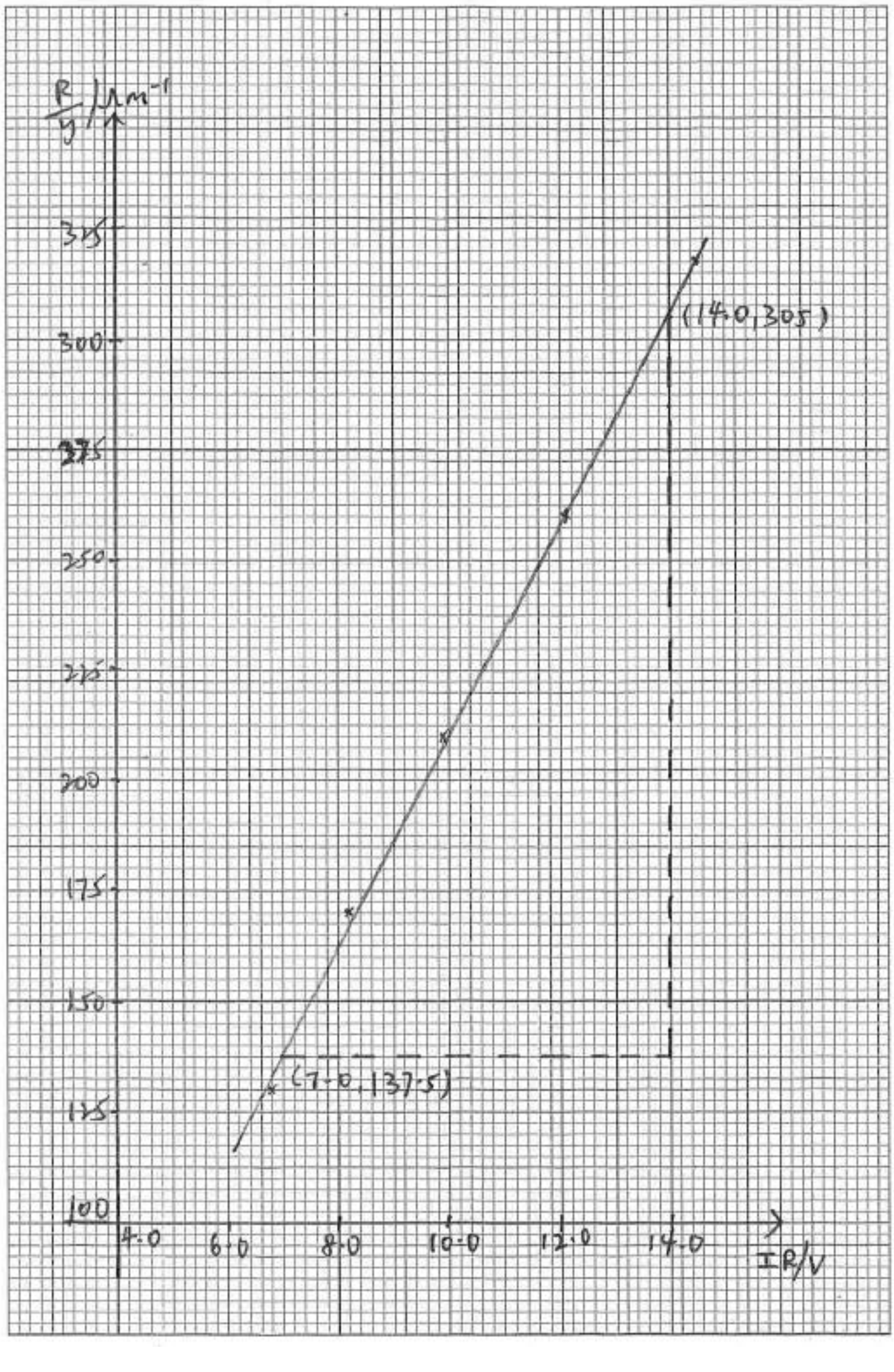
Since $\frac{Q}{F} = 23.9$
$\Rightarrow \frac{29.6}{F} = 23.9$
$F = 1.23$
F = 1.23 V
Q = 29.6 Ω m^{-1}</td><td>[1]
- Big triangle
- substitution of gradient coordinates

[1] $\frac{Q}{F}$ calculated correctly

[1] Q calculated correctly

[1] F calculated correctly

[1] Q and F with correct units</td></tr>
</table>


R/y / Ω m⁻¹
325
300
275
250
225
200
175
150
125
100
4.0
6.0
8.0
10.0
12.0
14.0
IR/V
(14.0, 305)
(7.0, 137.5)

1(d)	d_1 = 0.19 mm d_2 = 0.19 mm Diameter of wire, $d = \dfrac{0.19+0.19}{2} = 0.19$ mm Given $Q = \dfrac{4\rho}{\pi d^2}$ $\rho = \dfrac{Q\pi d^2}{4}$ $= \dfrac{29.6 \times \pi \times \left(0.19 \times 10^{-3}\right)^2}{4}$ $= 8.39 \times 10^{-7}\ \Omega$ m	[1] - correct measurements with unit and d.p - repeated measurement [1] ρ calculated correctly

<table>
<tr><th>No.</th><th>Solution</th><th>Remarks</th></tr>
<tr><td>2(a)(i)</td><td>$\theta_1 = 60°$
$\theta_2 = 60°$
$\theta = \dfrac{60° + 60°}{2} = 60°$</td><td>[1]
- correct measurements
- repeat measurement
- nearest degree</td></tr>
<tr><td>2(a)(ii)</td><td>$n_1 = 11$
$n_2 = 11$
$n = \dfrac{11 + 11}{2} = 11$</td><td>[1]
correct measurements
[1]
repeat measurement</td></tr>
<tr><td>2(b)</td><td>Given $n = k \tan\theta$

$k = \dfrac{n}{\tan\theta} = \dfrac{11}{\tan 60°} = 6.4$</td><td>[1]
k calculated correctly
[1]
answer for k in 2 s.f</td></tr>
<tr><td>2(c)</td><td>
<table>
<tr><th>θ/°</th><th>n_1</th><th>n_2</th><th>n</th><th>$k = \dfrac{n}{\tan\theta}$</th></tr>
<tr><td>60</td><td>11</td><td>11</td><td>11</td><td>6.4</td></tr>
<tr><td>70</td><td>14</td><td>14</td><td>14</td><td>5.1</td></tr>
<tr><td>80</td><td>26</td><td>26</td><td>26</td><td>4.6</td></tr>
</table>
</td><td>[1]
- headings and units
- 3 sets of data
- no d.p for raw data
- correct s.f for processed data

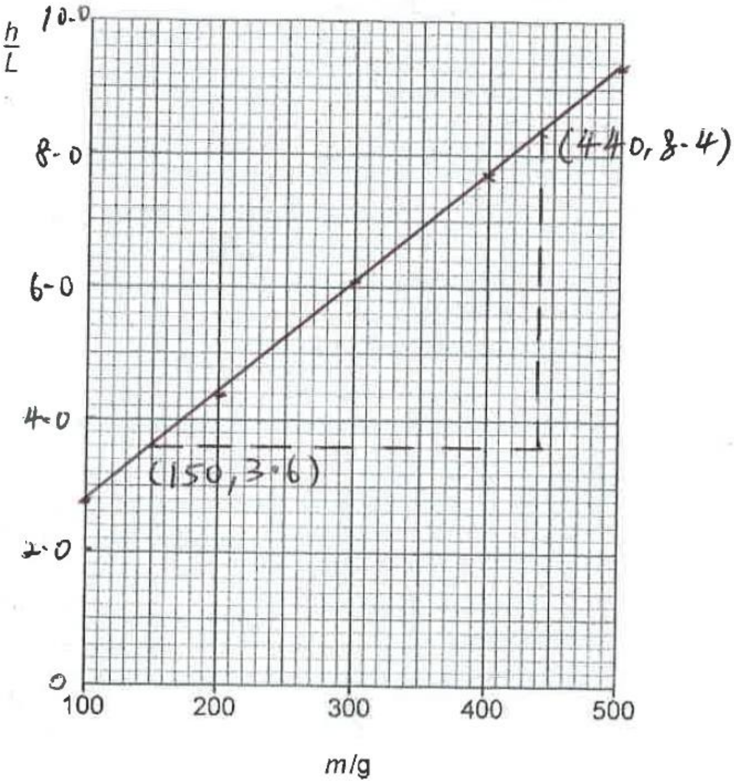
[1] correct calculation</td></tr>
<tr><td>2(d)</td><td>For $\theta = 90°$, the two pendulums will make contact with the wooden rod at the same length.

Hence both pendulums will always oscillate in phase.</td><td>[1]</td></tr>
</table>

<table>
<tr><th>No.</th><th>Solution</th><th>Remarks</th></tr>
<tr><td>3(a)(i)</td><td>$L = \dfrac{26.2+26.2}{2} = 26.2$ cm
$h = \dfrac{71.8+71.8}{2} = 71.8$ cm</td><td>[1]
- correct unit and measurement for h and L.
- repeat measurement</td></tr>
<tr><td>3(a)(ii)</td><td>$\dfrac{h}{L} = \dfrac{71.8}{26.2} = 2.74$</td><td>[1]
- correct calculation
- answer in 3 s.f</td></tr>
<tr><td>3(a)(iii)</td><td>Let $Y = \dfrac{h}{L}$
$\dfrac{\Delta Y}{Y} = \dfrac{\Delta h}{h} + \dfrac{\Delta L}{L}$
Percentage uncertainty in $\dfrac{h}{L} = \left(\dfrac{0.2}{71.8} + \dfrac{0.2}{26.2}\right) \times 100\%$
= 1 %</td><td>[1] for correct percentage uncertainty
(1 or 2 s.f.)

[1]
Accept Δh & ΔL = 0.2 or 0.3 cm</td></tr>
<tr><td>3(b)</td><td>
<table>
<tr><th>m/g</th><th>h/cm</th><th>L/cm</th><th>$\dfrac{h}{L}$</th></tr>
<tr><td>100</td><td>71.8</td><td>26.2</td><td>2.74</td></tr>
<tr><td>200</td><td>79.8</td><td>18.2</td><td>4.38</td></tr>
<tr><td>300</td><td>84.1</td><td>13.9</td><td>6.05</td></tr>
<tr><td>400</td><td>86.7</td><td>11.3</td><td>7.67</td></tr>
<tr><td>500</td><td>88.5</td><td>9.5</td><td>9.3</td></tr>
</table>
</td><td>[1]
- headings and units
- 5 sets of data
- d.p, units of raw data
- s.f of processed data

[1] correct calculation</td></tr>
</table>

3(c)(i)		[1] - all points plotted correctly - best fit line drawn
3(c)(ii)	Gradient$=\frac{8.4-3.6}{440-150}=0.0166$ Given $\frac{h}{L}=\frac{2m}{X}+1$ Graph of $\frac{h}{L}$ vs m is plotted $\Rightarrow$ gradient = $\frac{2}{X}$ $\Rightarrow \frac{2}{X}$ = 0.0166 X = 120 g	[1] - substitution of gradient coordinates - value of X calculated correctly
3(d)	Mass X = $\frac{138.96+139.04}{2}=139.00$ g Percentage difference = $\frac{139-120}{120}\times 100\% = 16\%$ The percentage difference between two values of X is 16% which is <u>higher than the percentage difference in **(a)(iii),**</u> hence value in **(a)(iii)** does not explain the difference.	[1] - calculate the % difference of X - % difference higher than **(a)(iii)**
3(e)(i)	Mass M = 100 g = 1.00×10^{-3} kg Thickness t = $\frac{0.79+0.78+0.80}{3}=0.79$ mm Distance L = $\frac{26.8+26.8}{2}=26.8$ cm	[1] - correct unit and measurement of t - repeat measurement - correct d.p

	Width $u = \dfrac{1.3+1.3}{2} = 1.3$ cm Distance moved down by hacksaw blade, $a = \dfrac{14.6+14.5}{2} = 14.6$ cm Given $a = \dfrac{4MgL^3}{Yut^3}$ $\Rightarrow Y = \dfrac{4MgL^3}{aut^3} = \dfrac{4\times 100\times 10^{-3}\times 9.81\times\left(26.8\times 10^{-2}\right)^3}{14.6\times 10^{-2}\times 1.3\times 10^{-2}\times\left(0.79\times 10^{-3}\right)^3}$ $= 8.07\times 10^{10}$ Pa $= 80.7\times 10^{9}$ Pa $= 81$ GPa	[1] - correct unit and measurement of *u* - repeat measurement for *u* only - correct d.p [1] - correct measurement of *a* - repeat measurement - correct d.p [1] *Y* calculated correctly
3(e)(ii)	- difficulty in determining the vertical deflection *a* of the ruler. - slotted weights may not be securely attached to the end of the ruler which may result in movement or slipping of the weights.	[1] any one
3(e)(iii)	Y is the stiffness of the metal. The value of *Y* for wood is 12 GPa which is much lower than value of the metal in **(e)(i).** This mean the <u>wood is less stiff and more prone to deformation under load.</u> When the same load is placed at the end of the wooden beam with the same dimensions as the metal hacksaw blade, the <u>wooden beam will bend more and break.</u> (deflection for metal blade will be smaller and more linear).	 [1]

3(f)

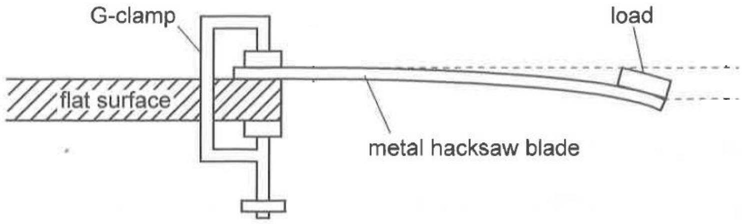


Fig. 1

1. Set up the apparatus as shown in Fig. 1.

2. Secure the metal hacksaw blade to the bench top tightly using the G-clamp. Ensure that the blade does not slip or shift during the oscillation.

3. Attach 100 g load to the end of the blade. Use Blu-Tack and rubber band to secure the load.

4. Measure the distance between the centre of the load and the edge of the surface *L* using ruler.

5. Set the load into oscillation by displacing the load slightly downwards.

6. Take the time taken for *N* oscillations using stopwatch and calculate the period $T = \dfrac{t_1 + t_2}{2N}$.

7. Calculate frequency of oscillation $f = \dfrac{1}{T}$.

8. Repeat the step **4** to **7** using different load *M* and *L*.

M/kg	L/m	Time for 40 oscillations		T/s	f^2/s^{-2}	Z/kg m^3 s^{-2}
		t_1/s	t_2/s			
0.100	0.268	26.7	26.9	0.670	2.28	0.00439
0.200	0.243	24.4	24.2	0.608	2.71	0.00778

Safety Precautions:
- Wear gloves to prevent cut and scratches.

- Ensure the G-clamp holding the metal blade is secured and does not slip.

- Maintain safe distance from the oscillating blade to avoid injury.

- Oscillating with small amplitude to avoid large and uncontrolled swing.

[1]
workable set up & label the diagram

[2]
Correct and detailed procedure

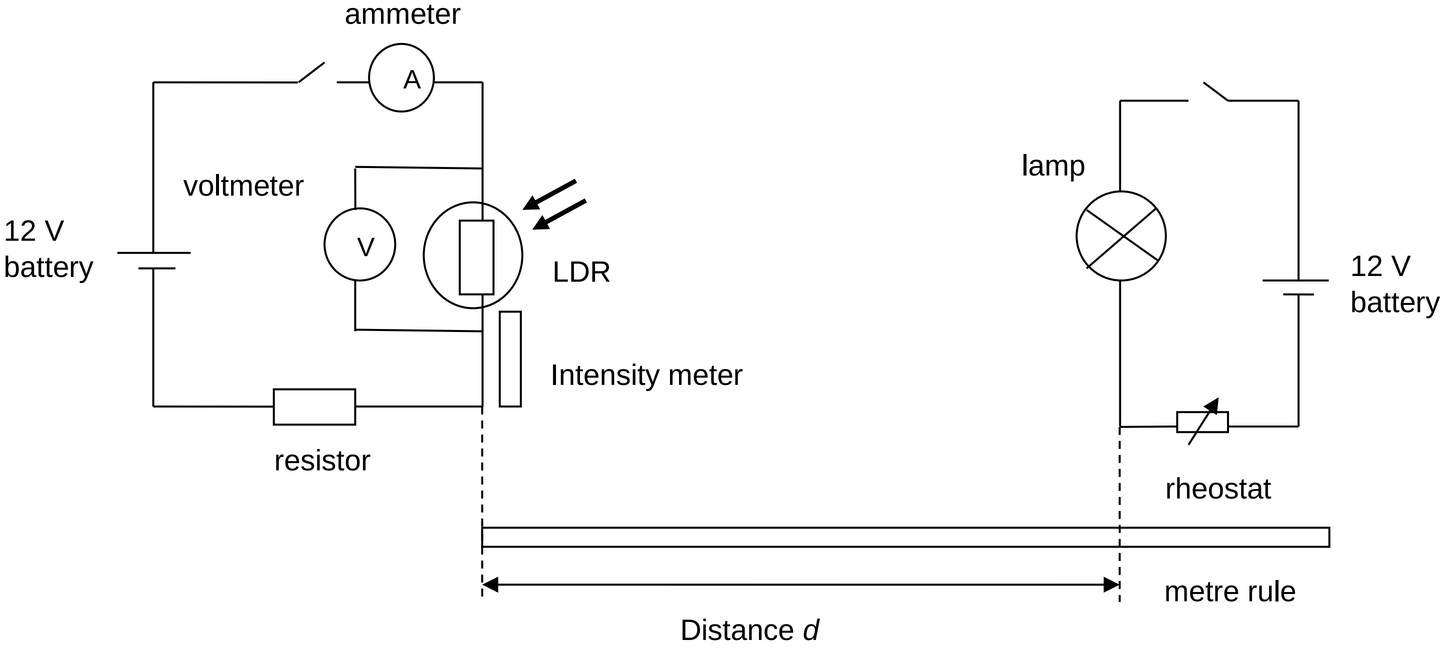
[1]
-heading with unit
[2]
Z calculated correctly

- Minus [1] if t_1 & $t_2 < 20$ s

- Two sets of *M* and *L* **must be different**

[1]
any one safety precaution

Diagram



4	**Aim:** To investigate how the resistance *R* of the LDR depends on the intensity I of the incident light and distance *d* from the lamp. **Diagram** Refer to diagram above.	[2] feasible set up and labelled diagram, e.g. - correct circuit diagram - voltmeter // LDR - ammeter in series with LDR - orientation of lamp and LDR - ruler measuring distance d - intensity meter measuring intensity of source
	Experiment 1 – to determine *p* **Independent variable**: Distance *d* from the lamp **Dependable variable**: Resistance *R* of the LDR **Controlled variable**: - Intensity I of the incident light - Alignment of lamp with LDR - Ambient light intensity	[1] correct variables for Experiment 1

	Procedure: **a)** Set up the apparatus as shown in the diagram above. **b)** Measure the distance *d* between the lamp and the LDR using a metre rule. Set *d* = 10.0 cm. **c)** Place the intensity meter beside the LDR. Close the circuit. **d)** Switch off the light in the laboratory and switch on the lamp and shine it on the LDR. **e)** Check the intensity of the lamp using a intensity meter to ensure that it is constant during the experiment. **f)** Measure the potential difference across the LDR and the current flowing through the circuit using voltmeter and ammeter respectively. **g)** Record the voltmeter and ammeter readings. The resistance of the LDR can be calculated using $R = \frac{V}{i}$ **h)** Increase the distance *d* and repeat step **(e)** to **(g)** to get six readings of *V*, *i* and *R*. **i)** Based on the equation $R = k\,d^{\,p}\,I^{\,q}$, we get $\lg R = p\lg d + \lg(kI^q)$. Plot a graph of lg *R* against lg *d*, where *p* is the gradient. **Experiment 2 – to determine *q*** **Independent variable**: Intensity I of the incident light **Dependable variable:** Resistance *R* of the LDR **Controlled variable**: - Distance *d* from the lamp - Alignment of lamp with LDR - Ambient light intensity **j)** Repeat **(e)** to **(g)** using lamp of different intensity at the same distance *d* to get six readings of *V*, *i* and *R*. **k)** Based on the equation $R = k\,d^{\,p}\,I^{\,q}$, we get $\lg R = q\lg I + \lg(kd^p)$. Plot a graph of lg *R* against lg I, where *q* is the gradient.	[2] for correct and detailed procedure [1] mention of apparatus for different measurement – distance *d* from LDR, - intensity I of the lamp, - potential difference *V* across LDR - current *i* [1] correct graph plotted [1] correct variable for Experiment 2 [1] correct graph plotted

	Precautions for accuracy: **1.** Conduct preliminary experiments by choosing the longest distance *d* and maximum intensity I so as to obtain a workable range for *R*. **2.** The lamp and the LDR can be fixed at a particular position using adhesive tape. **3.** In Experiment 2, the rheostat can be adjusted to vary the current flowing through the lamp, hence changing the intensity of the lamp. **4.** The experiment should be conducted in a dark room so that the intensity of other light sources would not interfere with the variation of the resistance of the LDR. **5.** The intensity meter, lamp and the LDR can be placed in a black cardboard tube/container to minimize the light from the surroundings from reaching the LDR or intensity meter. **Precautions for safety:** **1.** Do not look directly at the lamp. Wear sun glasses if the intensity of the lamp is too high. **2.** Do not touch the lamp with bare hands. Wear gloves when handling the lamp.	[1] any 1 [1] any 1