Suggested Answers to 2021 JC2 Preliminary Examination Paper 4 (H2 Physics)

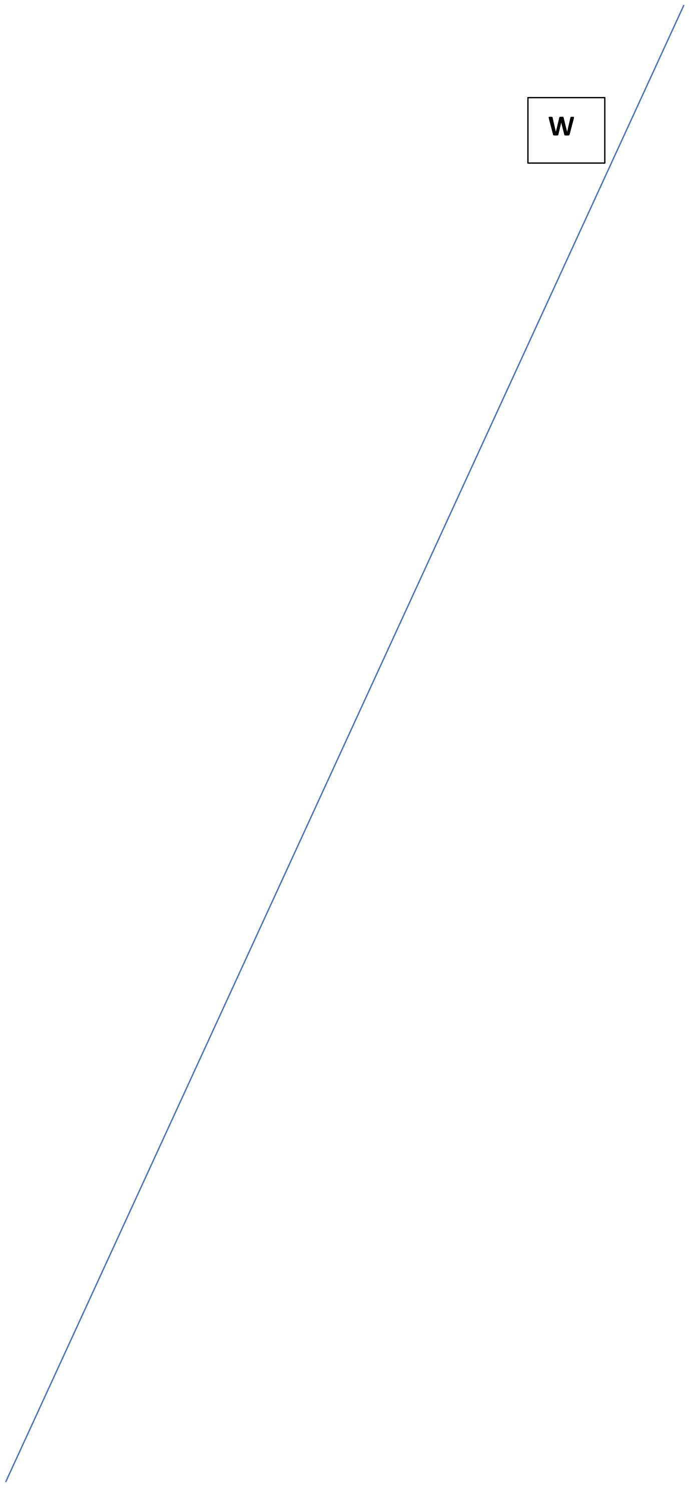
<table>
<tr><th>No.</th><th>Solution</th><th>Remark</th></tr>
<tr><td>1(a)(i)</td><td>length = 1.000 m
$R_A = 16.2\ \Omega\ \text{m}^{-1}$
$R_B = 28.4\ \Omega\ \text{m}^{-1}$</td><td>[1] unit and 3 s.f.
[1] range
($15 \le R_A \le 17$)
($27 \le R_B \le 33$)</td></tr>
<tr><td>1(a)(ii)</td><td>$d = \dfrac{0.24 + 0.22 + 0.23}{3} = 0.23\ \text{mm}$</td><td>[1]
- repeat at least twice
- 2 d.p. in mm
($0.15 \le d \le 0.25$)</td></tr>
<tr><td>1(a)(iii)</td><td>$R_A L_A = \dfrac{\rho L_A}{\pi \left(d/2 \right)^2}$
$(16.2)(1.000) = \dfrac{\rho(1.000)}{\pi \left(0.23 \times 10^{-3}/2 \right)^2}$
$\rho = 6.7 \times 10^{-7}\ \Omega\ \text{m}$</td><td>[1]
- ans (10^{-7} Ωm)
- unit
- 2 or 3 s.f.

(e.c.f.)</td></tr>
<tr><td>1(b)</td><td>$L = \dfrac{50.0 + 50.0}{2} = 50.0\ \text{cm}$
$x = \dfrac{60.0 + 60.0}{2} = 60.0\ \text{cm}$
$I = 0.2151\ \text{A}$</td><td>[1]
L and x, 3 d.p. in m
(49cm $\le L \le$ 51cm)

[1]
I 1 d.p. in mA,
or 4 d.p. in A</td></tr>
<tr><td>1(c)</td><td>
<table>
<tr><th>x/m</th><th>I /A</th><th>$\dfrac{1}{x}$ / m^{-1}</th></tr>
<tr><td>0.600</td><td>0.2151</td><td>1.67</td></tr>
<tr><td>0.700</td><td>0.2079</td><td>1.43</td></tr>
<tr><td>0.800</td><td>0.2021</td><td>1.25</td></tr>
<tr><td>0.850</td><td>0.1998</td><td>1.18</td></tr>
<tr><td>0.900</td><td>0.1975</td><td>1.11</td></tr>
<tr><td>0.950</td><td>0.1956</td><td>1.05</td></tr>
</table>
Accept $\dfrac{1}{R_B x} / \Omega^{-1}$ and $\left(\dfrac{1}{R_A L} + \dfrac{1}{R_B x} \right) / \Omega^{-1}$
</td><td>[1]
- heading, units
- min range of x at least 30 cm above 50.0cm mark
- 6 sets of data

[1] - raw data’s d.p.

[1]- processed data correctly calculated and in 3 s.f.
(no mark if table only has x and I)</td></tr>
</table>


W

1(d)	Plot I against 1/x $\text{Gradient} = \frac{0.1966-0.2160}{1.080-1.690}$ $=0.03180$ $0.03180=\frac{E}{R_B}$ $0.03180=\frac{E}{28.4}$ $E=0.90312$ $=0.90\text{ V}$ Alternate method Use (1.080,0.1966) to find intercept $0.1966=(0.03180)(1.080)+\frac{E}{R_A L}$ $0.1966=(0.03180)(1.080)+\frac{E}{(16.2)(0.500)}$ $E=1.31\text{ V}$	Graph: [1] axis, units, scales [1] plotted points [1] best fit, correct trend, correct linearized equation Calculation: [1] gradient substitution with big gradient triangle [1] substitution to find E [1] calculated E
1(e)	New equation is $I=\frac{E}{R_A x}+\frac{E}{R_B L}$ Since $R_A<R_B$, W's gradient is larger, y-intercept is smaller	[1]

Penalise no-repeat once for this question.

2(a)	$l = \frac{17.8+17.8}{2}$ =17.8 cm	[1] - repeat, -1 d.p. in cm ($16.0 \le l \le 19.0$cm)
2(b)	H = $\frac{28.2+28.4}{2}$ = 28.3 cm	[1] - repeat, -1 d.p. in cm ($25.0 \le H \le 35.0$cm)
2(c)(i)	$b=\sqrt{l(H-l)}$ $=\sqrt{(17.8)(28.3-17.8)}$ $=13.7\text{ cm}$ $=0.137\text{ m}$	[1] substitution [1] ans e.c.f.
2(c)(ii)	$b=\sqrt{l(H-l)}$ $b^2=lH-l^2$ $l^2=lH-b^2$ Plot l^2 against lH. b is calculated using $-b^2$=vertical intercept b = (-vertical intercept)$^{1/2}$	[1] graph [1] method to find b

For each variable of C, θ and t, penalise once for – no repeat

– wrong / no unit (for k too)

No.	Solution	Remark
3(a)(ii)	$\theta = \dfrac{40^o + 40^o}{2} = 40^o$	[1] - no d.p. in degree - repeat - 39 ° to 41°
3(a)(iii)	percentage uncertainty in $\theta = \dfrac{2^o}{40^o} \times 100\% = 5\%$	[1] - $\Delta\theta = 2°$ to 4° - ans in 1 or 2 sf
3(a)(iv)	$\sin\left(\dfrac{40^o}{2}\right) = 0.34$	[1] - correct ans - 2 s.f.
3(b)(ii)	$C = \dfrac{24.5 + 24.4}{2} = 24.5$ cm percentage uncertainty in C $= \dfrac{0.2}{24.5} \times 100\% = 0.8\%$	[1] - 1 d.p. in cm - repeat C [1] 20 cm $\le C \le$ 30 cm [1] - $\Delta C = 0.2$ to 0.5 cm - ans in 1 or 2 sf
3(b)(iii)	$T = \dfrac{t_1 + t_2}{2N}$ $= \dfrac{22.8 + 22.7}{2(4)}$ $= 5.69$ s	[1] - t_1 , t_2 1 d.p. in s - t_1 , t_2 > 20s - repeated - T in 3 s.f. (T>2s)
3(c)	$\theta = \dfrac{70^o + 70^o}{2} = 70^o$ $\sin\left(\dfrac{70^o}{2}\right) = 0.57$ $T = \dfrac{t_1 + t_2}{2N}$ $= \dfrac{20.4 + 20.3}{2(2)}$ $= 10.2$ s	[1] - θ no d.p. in ° - θ > 40 ° - repeat - ans in 1 or 2 sf [1] - t_1 , t_2 1 d.p. in s - t_1 , t_2 > 20s - repeated - T in 3 s.f. - T in (c) > (b)

<table>
<tr>
<td>**3(d)(i)**</td>
<td>
<table>
<tr><th>θ/°</th><th>sin(θ/°)</th><th>t_1/s</th><th>t_2 /s</th><th>N</th><th>T/s</th></tr>
<tr><td>40</td><td>0.34</td><td>22.8</td><td>22.7</td><td>4</td><td>5.69</td></tr>
<tr><td>70</td><td>0.57</td><td>20.4</td><td>20.3</td><td>2</td><td>10.2</td></tr>
</table>

$T = kC\sin(\theta/2)\sqrt{m}$

$5.69 = k_1(0.245)(0.34)\sqrt{0.050}$

$k_1 = 305\ \text{s m}^{-1}\ \text{kg}^{-0.5}$

$T = kC\sin(\theta/2)\sqrt{m}$

$10.2 = k_2(0.245)(0.57)\sqrt{0.050}$

$k_2 = 327\ \text{s m}^{-1}\ \text{kg}^{-0.5}$
</td>
<td>[1]
Both values of k correct with units</td>
</tr>
<tr>
<td>**3(d)(ii)**</td>
<td>
Percentage difference of k = $\dfrac{327-305}{305}\times 100\% = 7.2\%$
percentage uncertainty in θ and C are 5% and 0.8%

Since percentage difference of k is larger than the percentage uncertainty in θ and C, the experiment does not support the relationship.
</td>
<td>[1]
- calculate % diff of k

- conclude by comparing with % uncertainties of θ and C.</td>
</tr>
<tr>
<td>**3(e)(i)**</td>
<td>
C = 0.120 m
θ = 40°
sin(40/2) = 0.34

<table>
<tr><th>t_1/s</th><th>t_2 /s</th><th>N</th><th>T/s</th></tr>
<tr><td>22.5</td><td>22.4</td><td>9</td><td>2.49</td></tr>
<tr><td>24.3</td><td>24.2</td><td>9</td><td>2.69</td></tr>
</table>

$T = kC\sin(\theta/2)\sqrt{m}$

$2.49 = k_3(0.120)(0.34)\sqrt{0.050}$

$k_3 = 273\ \text{s m}^{-1}\ \text{kg}^{-0.5}$

$T = kC\sin(\theta/2)\sqrt{m}$

$2.69 = k_4(0.120)(0.34)\sqrt{0.050}$

$k_4 = 295\ \text{s m}^{-1}\ \text{kg}^{-0.5}$
</td>
<td>[1]
- table heading with units
- all data in correct d.p.
- θ : 39° to 41°
- $C < 13$ cm

[1]
K_1 correct calculation and units

[1]
K_2 correct calculation and units</td>
</tr>
<tr>
<td>**3(e)(ii)**</td>
<td>
Percentage difference of k in (e) =
$\dfrac{295-273}{273}\times 100\% = 8.1\%$

Percentage difference of k in (d) and (e) are around 7 and 8%.
</td>
<td>[1]
- compare % diff of k in (d) and (e)</td>
</tr>
</table>

	Magnitudes of *k* in (d) are 305 and 327, while those in (e) are 273 and 295. The values of *k* in (d) are larger than those in (e). (is there is no obvious relationship, comment that “there’s no relationship”)	[1] - compare values of *k* in (d) and (e)
3(f)(i)	- Use the longer wire and set up the apparatus according to Fig. 3.2. Use *n* the number of loops in the rubber band as 3. Follow step **(b)(iii)** to determine period *T*. - keep *C*, θ, *m* constant - Repeat the experiment by increasing more loops of the rubber band to obtain 6 different values of *n* and *T*. Calculate $\frac{1}{n}$. - Plot a graph of *T* against $\frac{1}{n}$. If a straight line graph through the origin is obtained, then the relationship is proven. (Accept lg*T* vs lg *n* with gradient = -1 ,but cannot pass through origin) - There is a limit to how many times the rubber band can be looped to increase *n* as the circumference of the band is not big enough.	[1] simple steps to obtain data [1] - constants - repeat to vary *n* [1] - plot graph -straight line conclusion [1] limited *n*
3(f)(ii)	To enable more number of loops *n*, use rubber band with a smaller width (cross sectional area). Accept longer rubber band	[1]

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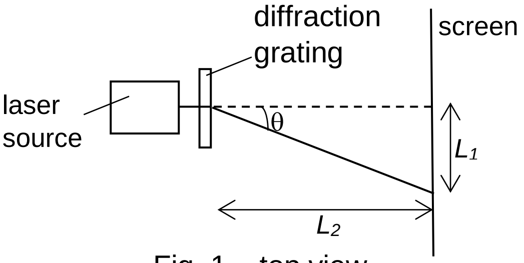
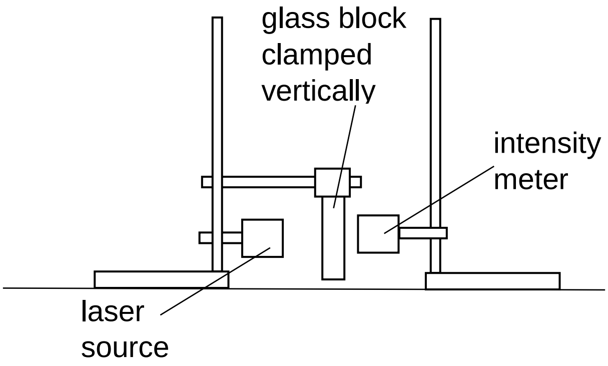
Solution	Remarks
To investigate the relationship between the transmittance τ of light and the wavelength *λ* of light and thickness *t* of glass, by determining *n* and *m*. Equation : $\tau = k\ \lambda^n t^m$ <u>Diagram</u>	
 Fig. 1 – top view	<u>Diagram:</u> [1] Fig 1: Laser source, diffraction grating, measurements to take
 Fig. 2 – side view	<u>Diagram:</u> [1] Fig 2: Glass, laser source, intensity meter

Procedure : a) Set up the apparatus as shown in Fig 1 and Fig. 2 b) Determine the wavelength λ by passing the laser light through a diffraction grating with slit separation d as shown in Fig 1. Determine θ using $\tan\theta = \frac{L_1}{L_2}$ where L_1 is distance from central maxima to 1st order maxima, L_2 is distance from grating to screen. Determine λ using $d\sin\theta = n\lambda$ c) Measure the thickness t of glass block using Vernier calipers d) Record the intensity I_o of the incident light using intensity meter Record the intensity I of the transmitted light using intensity meter Calculate $\tau = \frac{I_o}{I}$	Procedure: Measurements, calculations for: [1] λ. [1] t [1] τ
To determine n: $\tau = (kt^m)\lambda^n$ Independent variable: λ Dependent variable: τ, Controlled variables: t	To find n: [1] variables for experiments to find n.
e) Replace the laser with a different wavelength and repeat the experiment to get 6 different sets of I_o, I, τ, L_1, L_2, θ, λ.	[1] Instructions on how to get 6 sets of data
f) From $\tau = (kt^m)\lambda^n$, get $\lg\tau = n(\lg\lambda) + \lg(kt^m)$ Plot a graph of $\lg\tau$ against $\lg\lambda$. n = gradient	[1] instructions on what graph to plot and how to find n.

To determine m: $\tau = (k\lambda^n)t^m$ Independent variable : t Dependent variable : τ Controlled variables : λ	To find m: [1] variables for experiments to find m.
f) Using the same wavelength laser, repeat b) to d) by stacking more pieces of glass together to obtain 6 sets of d, I_0, I, τ.	[1] Instructions on how to get 6 sets of data
g) From $\tau = (k\lambda^n)t^m$, get lgτ = m(lg$t$) + lg($k\,\lambda^n$) Plot a graph of lgτ against lg t. m = gradient	[1] instructions on what graph to plot and how to find m.
Precautions for accuracy 1) Measurements of t and λ should be repeated and average calculated to reduce random errors. 2) Positons of the laser, glass, intensity meter should be kept at the same level. 3) Experiment can be conducted in dark room to prevent ambient light sources.	[1] accuracy
Precautions for safety Do not point the laser at anyone to prevent injury to the eyes.	[1]
	Total of 12