Candidate 5 evidence

Verifying the Refractive Index of Water

Aim: To verify the refractive index of water

Underlying Physics: The refractive index of a material is the measure of how light is bent when entering a new medium. When the light is coming directly into the new material from a vacuum it is known to be the absolute refractive index of that material. As the refractive index increases so too does the degree of the angle of refraction.

When plotting a graph of the angle of incidence against the angle of refraction it will appear that the relationship between the two is not clear and doesn't produce a straight line through the origin. Therefore to plot a graph correctly which will show a relationship of the two being directly proportional, the sine of the angle of incidence must be plotted against the sine of the angle of refraction, which should produce a straight line through the origin. The straight line through the origin shows that the two axes are directly proportional:

$$\sin\theta_1 \propto \sin\theta_2.$$

The gradient of the straight line should provide an accurate value of the refractive index of the material. When light travels into the new medium the ratio of $\sin\theta_1$ to $\sin\theta_2$ is a constant unless the light enters the medium at 90°.

The absolute refractive index, n, of a material is the ratio

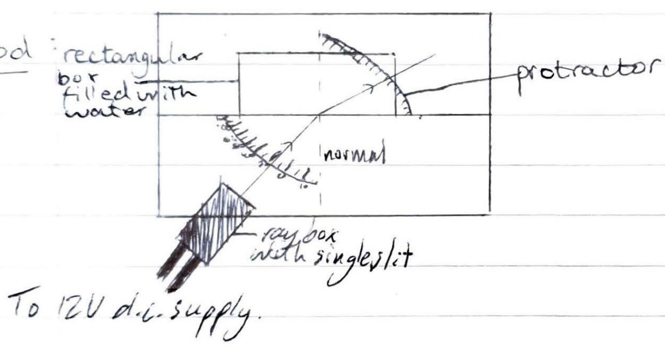
$\frac{\sin\theta_1}{\sin\theta_2}$ where θ_1 is in a vacuum and θ_2 is in the medium. This gives Snell's Law:

$$n = \frac{\sin\theta_1}{\sin\theta_2}$$

where: n = absolute refractive index of the medium
$\sin\theta_1$ = angle of incidence in a vacuum
$\sin\theta_2$ = angle of refraction in the medium.

In practice, we can use $n = \frac{\sin\theta_{air}}{\sin\theta_{medium}}$ (1)

Method:



During my experiment I moved the ray box from 10° through to 70°. Each time I changed the angle of incidence I ~~[illegible]~~ recorded the angle of refraction shown on the protractor. I repeated these steps until I had all my data.

Results

Angle of Incidence θ_1 (°)	Angle of Refraction, θ_2 (°) 1	2	3	4	Mean	Scale Reading Uncertainty	Random Uncertainty	Dominant Uncertainty	Percentage Uncertainty
10	7	9	8	8	8	0.5	0.5	0.5	6.25%
20	16	14	15	15	15	0.5	0.5	0.5	3.33%
30	23	23	24	22	23	0.5	0.5	0.5	2.17%
40	27	28	29	28	28	0.5	0.5	0.5	1.79%
50	36	33	35	34	34.5	0.5	0.75	0.75	2.17%
60	38	39	40	39	39	0.5	0.5	0.5	1.28%
70	42	45	44	45	44	0.5	0.75	0.75	1.70%

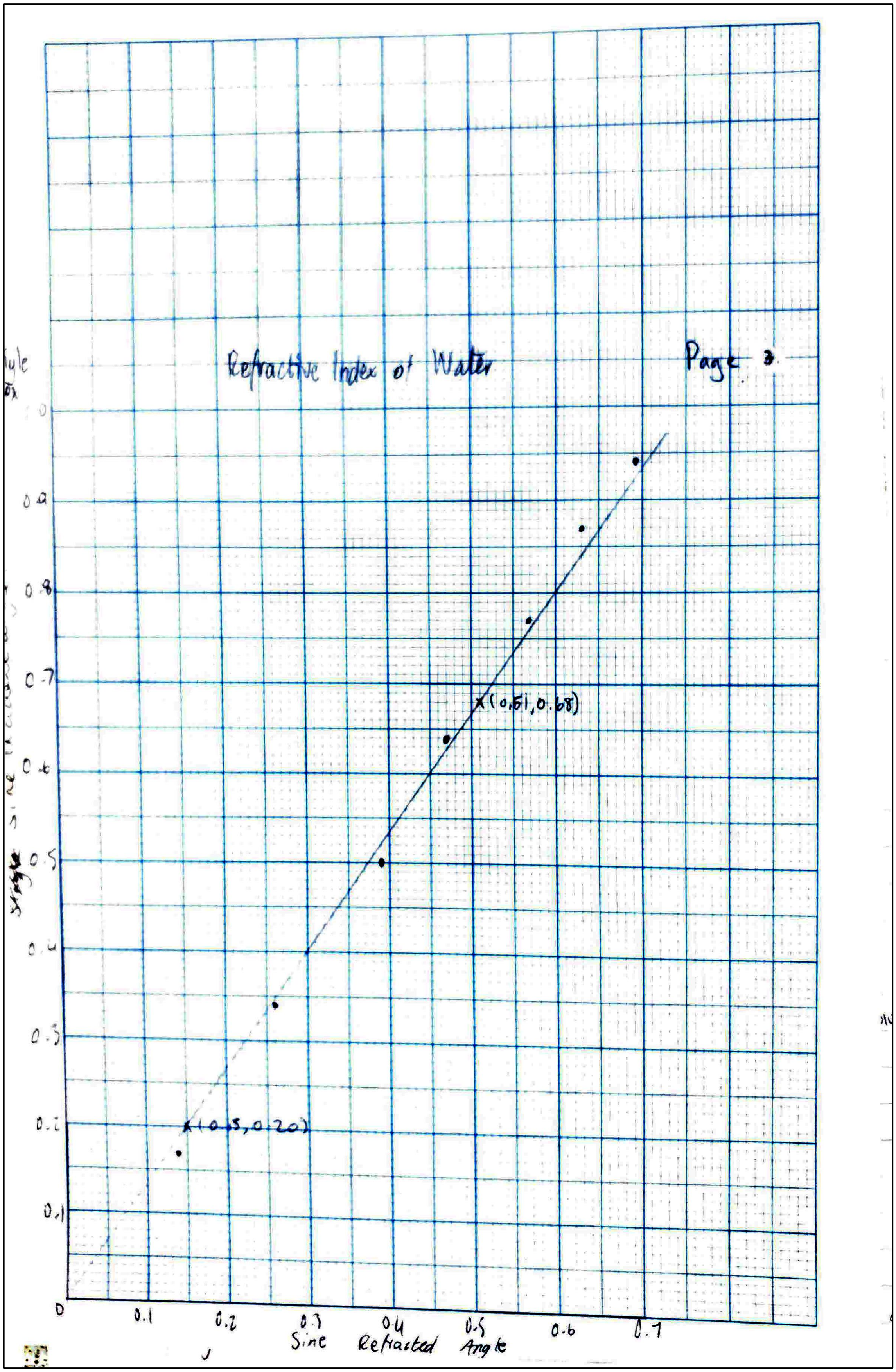
dominant percentage

$7+9+8+8 = \frac{32}{4} = 8$

$\frac{9-7}{4} = \frac{2}{4} = 0.5$

$\% \theta = \frac{0.5}{8} \times 100$

$= 6.25\%$


Refractive Index of Water
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x(0.51, 0.68)
x(0.15, 0.20)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
Sine Refracted Angle

Graph data

$\sin\theta_1$	$\sin\theta_2$
0.17	0.14
0.34	0.26
0.50	0.39
0.64	0.47
0.77	0.57
0.87	0.63
0.94	0.69

$\sin 10 = 0.1736...$

Uncertainties

Scale Reading $= \pm 0.5°$ for protractor.

Random Uncertainty

Angle of Refraction, θ_2 (°) 1	2	3	4	Random Uncertainty
7	9	8	8	0.5
16	14	15	15	0.5
23	23	24	22	0.5
27	28	29	28	0.5
36	33	35	34	~~3/4~~ 0.75
38	39	40	39	0.5
42	45	44	45	0.75

$9 - 7 = \frac{2}{4} = 0.5$

Analysis

$(\overset{x^1}{0.15}, \overset{y^1}{0.20})(\overset{x^2}{0.51}, \overset{y^2}{0.68})$

$m = \frac{y^2 - y^1}{x^2 - x^1}$

$= \frac{0.68 - 0.20}{0.51 - 0.15}$

$= \frac{0.48}{0.36}$

$= 1.333...$

$= 1.33$

Second Data Source (page 5)

$(\overset{x^1}{0.1397959}, \overset{y^1}{0.1827101})(\overset{x^2}{0.615120}, \overset{y^2}{0.8290109})$

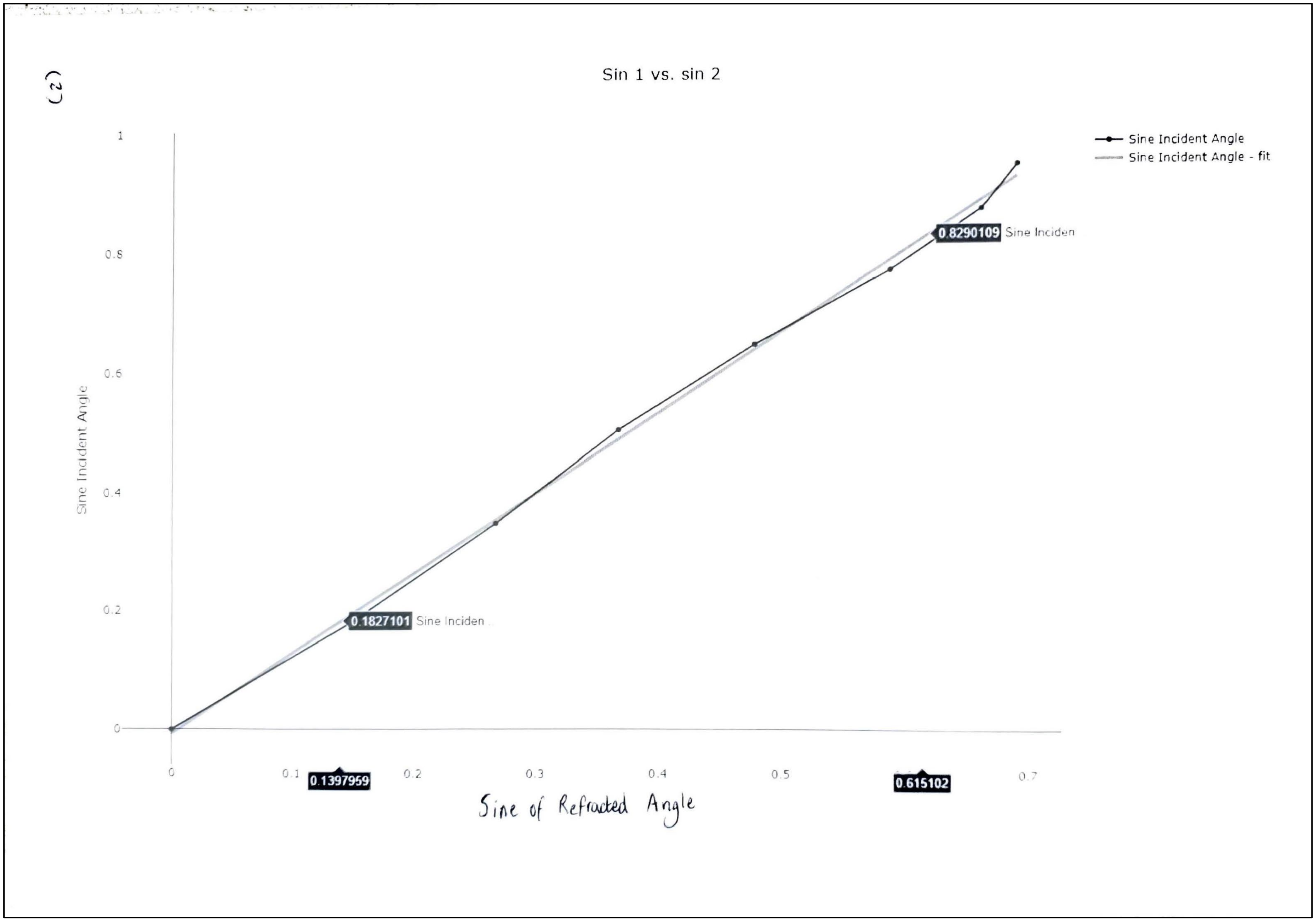
$m = \frac{y^2 - y^1}{x^2 - x^1}$

$= \frac{0.8290109 - 0.1827101}{0.615120 - 0.1397959}$

$= 1.3597...$

$= 1.36$

My experimental data provides a value closer to the correct value of


(2)
Sin 1 vs. sin 2
Sine Incident Angle
Sine Incident Angle - fit
0.8290109 Sine Inciden
0.1827101 Sine Inciden
Sine Incident Angle
1
0.8
0.6
0.4
0.2
0
0
0.1
0.1397959
0.2
0.3
0.4
0.5
0.615102
0.7
Sine of Refracted Angle

the refractive index of water

Conclusion After plotting a graph of $\sin\theta_1$ against $\sin\theta_2$, I calculated the gradient of the graph which should give me the value of refractive index my data provides. The value calculated from my graph was $1.33 \pm 6.25\%$ and the correct value for the refractive index of water should be 1.33. This shows that when allowing uncertainties I have therefore verified the refractive index of water.

Evaluation When I was carrying out my experiment I didn't check to see if the water was room temperature, to improve my experiment I would ensure that the water is at room temperature when taking all my data.

The box that I used to contain the water was a rectangle and when the refracted ray of light neared the corners of the box the protractor reading became difficult to read. To improve the accuracy of my readings I could use a semi-circular box to contain the water as there will be no square edges to potentially make it more difficult to read the protractor value.

To further improve my experimental data I could repeat each angle of incidence a few more times to reduce the random uncertainty in my results.

References
1 - Bright Red Study Guides CFE Higher Physics, John Taylor, page 108, ISBN: 978-1-906736-67-5

2 - https://plot.ly/~zamelia11/5.embed November 2018