PH-291 Physics Lab
Professor Corn-Agostini
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Lab # 2: Index of Refraction

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Read and sign Academic Integrity Statement:

I hereby attest that I have not given or received any unauthorized assistance on this assignment.

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Grading Rubric

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1 Purpose

In this lab, Pfund's Method and Snell's Law will be used to determine the index of refraction of an unknown liquid. Two methods will be used to find this index of refraction, the first utilizing Pfund's Method, while the second uses Snell's Law. The index of refraction of the glass petri dish is determined via Pfund's Method. This then allows us to proceed with both methods. As light is refracted through a medium, a small circular region is observed, surrounded by a darker region with a radius that can be used to calculate the unknown index of refraction via Pfund's Law. In the second method, the incident and reflected angles of the light are measured and plugged into Snell's Law. We can compare the two calculated values to determine the unknown substance.

2 Data

Measurement	Thickness (mm)
1	1.695
2	1.995
3	1.990
4	2.095
5	1.930
6	1.995
Instrumental Error: 0.005 mm	
Random Error: 0.055 mm	
Thickness: 1.950 ± 0.055 mm	

Table 1: Petri Dish Thickness

Measurement	Thickness (mm)
1	7.98
2	8.86
3	8.24
4	7.60
5	8.16
6	7.66
Instrumental Error: 0.02 mm	
Random Error: 0.19 mm	
Thickness: 8.08 ± 0.19 mm	

Table 2: Ring Diameter Without Liquid

Measurement	Diameter (mm)
1	19.68
2	19.60
3	19.58
4	19.58
5	19.56
6	19.62
Instrumental Error: 0.02 mm	
Random Error: 0.017 mm	
Thickness: 19.60 ± 0.02 mm	

Table 3: Ring Diameter With Liquid

Measurement	**Incident Angle**	**Refracted Angle**
1	50.0°	28.0°
2	28.0°	38.0°
3	36.0°	20.0°
4	17.0°	40.0°
5	43.0°	27.0°
6	28.0°	39.0°
Instrumental Error: 0.5°		

Table 4: Snell's Law

3 Calculations

Pfund's Method

1. Index of Refraction (n_{glass})

$$n_{\text{glass}} = \frac{\sqrt{d^2 + 16t^2}}{d}$$

Error Propagation:

1.1 Partial Derivative of Eq. 1 w.r.t d

$$\frac{\partial n_{\text{glass}}}{\partial d} = -\frac{16t^2}{d^2\sqrt{d^2 + 16t^2}}$$

1.2 Partial Derivative of Eq. 1 w.r.t t

$$\frac{\partial n_{\text{glass}}}{\partial t} = \frac{16t}{d\sqrt{16t^2 + d^2}}$$

1.3 Total Error Associated with the Index of Refraction (n_{glass})

$$\delta n_{\text{glass}} = \sqrt{\left(\frac{\partial n_{\text{glass}}}{\partial t}\delta t\right)^2 + \left(\frac{\partial n_{\text{glass}}}{\partial d}\delta d\right)^2}$$

2. Index of Refraction (n_{liquid})

$$n_{\text{liquid}} = \frac{n_{\text{glass}} d}{\sqrt{d^2 + 16t^2}}$$

Error Propagation:

2.1 Partial Derivative of Eq. 2 w.r.t d

$$\frac{\partial n_{\text{liquid}}}{\partial d} = \frac{16 n_{\text{glass}} t^2}{(d^2 + 16t^2)^{\frac{3}{2}}}$$

2.2 Partial Derivative of Eq. 2 w.r.t t

$$\frac{\partial n_{\text{liquid}}}{\partial t} = -\frac{16 d n_{\text{glass}} t}{(16t^2 + d^2)^{\frac{3}{2}}}$$

2.3 Partial Derivative of Eq. 2 w.r.t n_{glass}

$$\frac{\partial n_{\text{liquid}}}{\partial n_{\text{glass}}} = \frac{d}{\sqrt{16t^2 + d^2}}$$

2.4 Total Error Associated with the Index of Refraction (n_{liquid})

$$\delta n_{\text{liquid}} = \sqrt{\left(\frac{\partial n_{\text{liquid}}}{\partial t}\delta t\right)^2 + \left(\frac{\partial n_{\text{liquid}}}{\partial d}\delta d\right)^2 + \left(\frac{\partial n_{\text{liquid}}}{\partial n_{\text{glass}}}\delta n_{\text{glass}}\right)^2}$$

Snell's Law

3. The Law of Refraction (Snell's Law)

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Error Propagation

3.1 Partial Derivative of Eq. 3 w.r.t $\boldsymbol{\theta}_1$