Newton's Rings

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1 Introduction

The goal of this experiment was to observe the diameter of rings in Newton's Rings in order to calculate and measure the radius of curvature of a glass lens, as well as to measure the index of refraction of water.

2 Theory

When light hits a half-concave, half-flat lens from above, when the concave side of the lens is facing downwards on a reflective surface, we observe circular interference patterns called Newton's Rings. This is caused by a light source being partially reflected and partially refracted at the lens' surface.

The path difference is given by (eq. 1)

$$L = 2nt_m \tag{eq. 1}$$

where n is the index of refraction of the material in the gap between the lens and reflective surface and t_m is the length of the gap between the lens and surface.

Dark circles will appear in places where the length of the gap t_m are equal, so we observe circular rings.

Let R be the radius of curvature of the concave lens, we can find that the diameter d of the mth ring from the center has the relation shown in (eq. 2).

$$d_m^2 = (\frac{4R\lambda}{n})m \tag{eq. 2}$$

Where λ is the wavelength of the light source and n is the same index of refraction from (eq. 1).

In this experiment, we directly observe d_m and look to measure the radius of curvature R and refractive index n for water.

3 Experimental Equipment and Method

3.1 Apparatus

The apparatus is shown in Figure **??**.

The vernier scale for the microscope which we used to measure the diameters have an accuracy of $\pm 0.005[mm]$.

We also use a drop of water to put between the surface and lens. Our source of monochromatic light is a sodium lamp with wavelength λ of 589.3 [nm] [2].

3.2 Protocol

The experiment protocol is described below:

- Set the glass plate and lens as shown in Figure **??**.

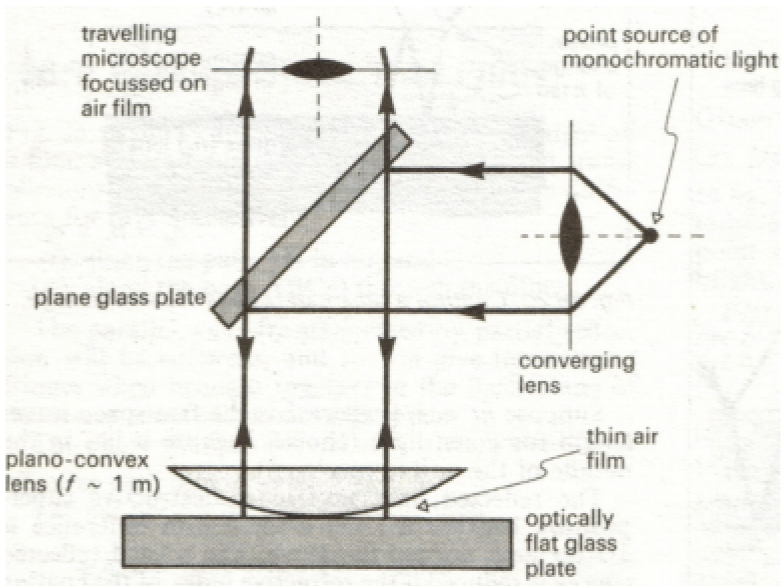

Figure 1: Schematic of Newton's rings experiment

- Turn on the sodium lamp and locate the center of the Newton's Rings
- Using the vernier scale measure the radius to the left of the center for 20 rings, and repeat for the right side as well.
- Add some water between the lens and surface, repeat the previous step for 10 radii.

4 Results

Our results are summarized in Table **??**

We plotted these values to find the gradient of the line, which should be $\frac{4R\lambda}{n}$ according to (eq. 2).

From this we calculated the following values for R:

$$R_{\text{air}} = 4.88 \pm 0.01 \times 10^{-1}[m]$$

and

$$R_{\text{water}} = 4.85 \pm 0.14 \times 10^{-1}[m]$$

We also calculate n to be:

$$n = 1.34$$

m	diameter^2 (mm^2)	diameter^2 water (mm^2)
0	0.000	0.000
1	0.865	0.960
2	1.769	1.960
3	3.386	2.993
4	4.494	3.881
5	5.429	4.494
6	6.401	5.523
7	7.508	6.401
8	8.880	7.023
9	10.368	7.952
10	11.492	8.585
11	12.745	9.548
12	13.913	
13	14.977	
14	16.000	
15	16.892	
16	18.063	
17	19.184	
18	20.340	
19	21.530	
20	22.848	

Table 1: Data for diameters squared

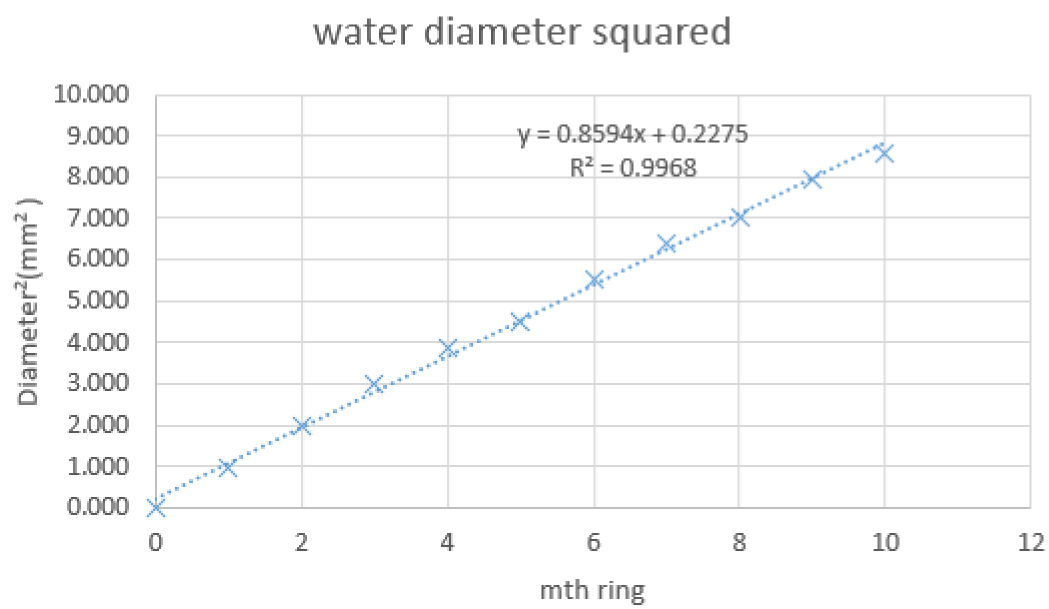

Figure 1: Diameter squared for water in t_m

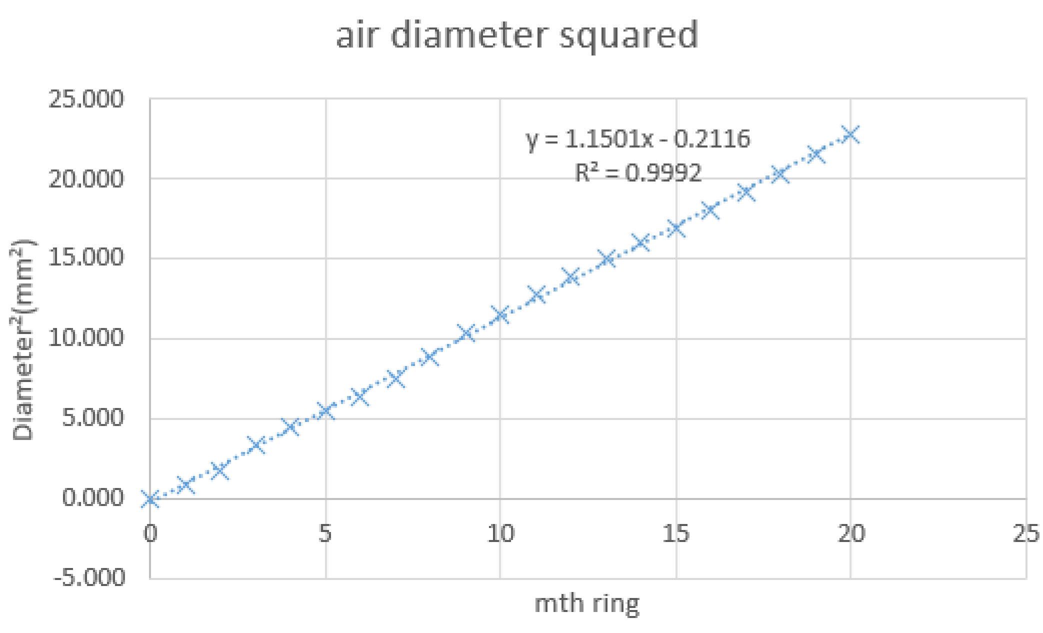

Figure 2: Diameter squared for air in t_m

5 Uncertainty Analysis

Using the data analysis package for microsoft excel, we find the relative uncertainty for our measurements of d^2 for water to be 0.03, and for air to be 0.01. Comparing to the known value for the refractive index of water, 1.33 [1], we find our measured refractive index to be fairly close.

6 Discussion and Conclusion

We find that our experiment was successful in finding the values we wished to measure with a surprising amount of accuracy.

Unfortunately, we were time constrained due to equipment troubles in the beginning followed by an interruption which consumed a significant portion of the lab time and our analysis was shallow.

References

[1] P J Mohr. "The 2014 CODATA Recommended Values of the Fundamental Physical Constants". In: (2016). URL: `http://physics.nist.gov/constants`.

[2] UPCSE. *Physics Laboratory Experiments*. 2018, pp. 1–80.