Teacher's Signature:____________
Date: ______________________

United International **University**

Name: Md. Mehedi Hassan ID: 011201205

Section: A Batch: 201 Date: ________________

Experiment No. 06

Name of the Experiment: Determination of the radius of curvature of a plano-convex lens by Newton's rings method.

Introduction

In this experiment the physical property of *interference of light* will be used to determine the radius of curvature of a plano-convex lens. The interference fringe system here is a pattern of concentric circles (See figure 3), the diameter of which you will measure with a travelling microscope (which has a Vernier scale). If a clean convex lens is placed on a clean glass slide (optically flat) and viewed in monochromatic light, a series of rings may be seen around the point of contact between the lens and the slide. These rings are known as *Newton's rings* (See figure 3.) and they arise from the interference of light reflected from the glass surfaces at the air film between the lens and the slide. The experimental set-up is shown in figure 1.

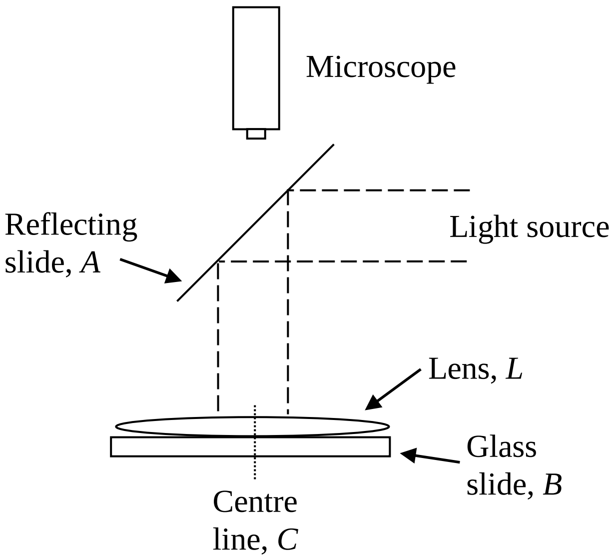


Figure 1: Apparatus

Theory:

Let R be the radius of curvature of the lower surface of the lens. Let r_n be the radius of the n^{th} dark ring, to be measured with the microscope.

Let the corresponding thickness of the air gap at the point P be t. (See figure 4.)

The path difference between the beams reflected at Q and P is approximately $2t$ (for vertical viewing, at small radius r).

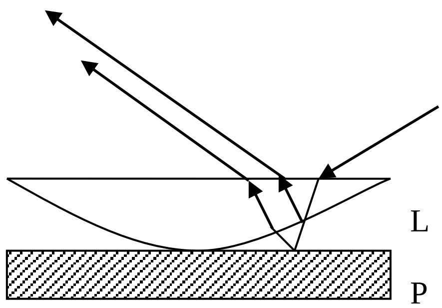


Figure 2

From geometry (refer to figure 5),

$R^2 = r_n^2 + (R-t)^2$

$$or, R^2 = r_n^2 + R^2(1-\frac{t}{R})^2$$

$$or, R^2 = r_n^2 + R^2(1-2\frac{t}{R}+\frac{t^2}{R^2})$$

Since $\left(\frac{t}{r}\right)^2$ is very small, we can neglect the term

$$\therefore R^2 = r_n^2 + R^2 - 2Rt$$

$$or, r_n^2 = 2Rt$$

But, we know, for dark fringes, $2t = n\lambda$

Thus, $r_n = \sqrt{nR\lambda}$

So, for n^{th} and $(n+p)^{th}$ ring we can write

$$D_n^2 = 4nR\lambda$$

$$and, D_{n+p}^2 = 4(n+p)R\lambda$$

Hence, we have,

$$D_{n+p}^2 - D_n^2 = 4pR\lambda$$

$$or, R = \frac{D_{n+p}^2 - D_n^2}{4p\lambda}$$

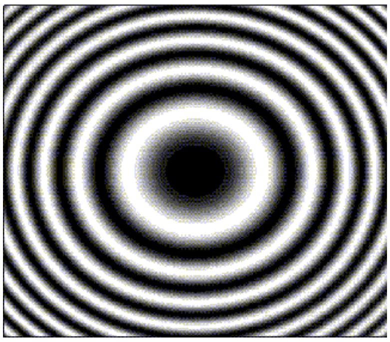


Figure 3: Newton's Rings

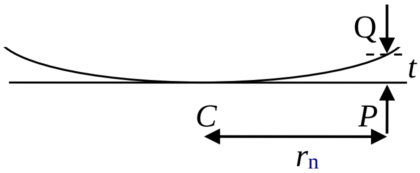


Figure 4

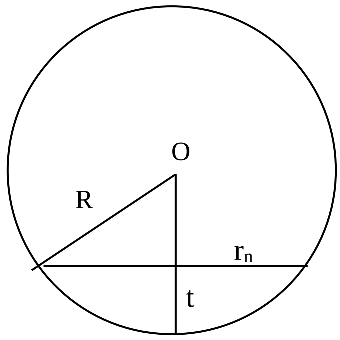


Figure 5: Determining D_n

Taking data to measure the radius of curvature of the plano-convex lens

In this part of the experiment you will measure the diameter of ten rings using the Vernier scale on the traveling microscope, and then use this data to determine the radius of curvature of the convex lens. .

The light from the sodium lamp is partially reflected downwards by a glass slide A. The beams reflected from the lens, L and the glass slide B goes through the slide A to the microscope.

Look for the interference rings with the naked eye – it is easiest to spot these from a height and changing your viewing angle. You may need to maneuver the reflecting slide until you can clearly view the rings.

Focus the microscope on the fringes and align the cross-hair tangential to the central dark spot.

Measure the diameters of at least ten dark rings by setting the cross-hair on one side of a series of rings, reading the positions and then moving the microscope to the other side of the corresponding rings.

You could start measuring the position of the 12th ring, proceeding to the 11th, 10th, etc. and then moving across to the other side of the central ring until you have measured the 12th ring again.

Read the Vernier scale precisely.

Draw a graph of $D_n^{\ 2}$ against the ring number (order number of the fringe) n.

Hence calculate the value of R from the graph.

Apparatus:

1) Traveling microscope 2) Plano-convex lens 3) Sodium lamp

Experimental Data:

Least Count: 0.001 cm

Ring no. (n)	Readings of the microscope								Diameter of ring, D = L~R (cm.)	D^2 (cm^2)
	Left Side (L)				Right Side (R)					
	L.S.R. x (cm.)	C.S.R.	Value of V.C.S.R. y (cm.)	Total, x+y (cm.)	L.S.R. x (cm.)	C.S.R.	Value of V.C.S.R. y (cm.)	Total, x+y (cm.)		
					2.26					
8	2.25	48	0.048	2.298	2.26	27	0.027	2.287	0.011	0.00012
7	2.26	21	0.021	2.281	2.26	17	0.017	2.277	0.004	.000016
6	2.30	25	0.025	2.325	2.55	34	0.034	2.584	0.25	0.062
5	2.30	34	0.034	2.334	2.55	25	0.025	2.575	0.24	0.057
4	2.35	43	0.043	2.343	2.55	9	0.009	2.559	0.21	0.044
3	2.35	12	0.012	2.362	2.5	43	0.043	2.543	0.18	0.032
2	2.40	30	0.030	2.430	2.55	28	0.028	2.578	0.14	0.020
1	2.40	43	0.043	2.443	2.55	10	0.010	2.560	0.12	0.014

Calculation:

R = (D2n+p - D2n)/ 4lamda * p
= 0.044-0.02/4*2*(5893*10^-8)
=50.91
Error rate = ((50.91-50)/50)*100% = 1.82 %
Accuracy rate = (100 -1.82) % = 98.18 %

Result:

The radius of curvature of the lower surface of the given lens, *R* = 50.91 cm

Discussions:

Q: Explain why do you observe the dark and bright colored fringes? Why is the central spot dark?

The bright lines indicate constructive interference and the dark lines indicate destructive interference. Also, the dark fringes residing on any side of the zero-order fringe is caused by destructive interference. The center of the ring dark in Newton's Rings experiment with reflected light is dark because at the point of contact the path difference is zero but one of the interfering ray is reflected so the effective path difference becomes λ/2 thus the condition of minimum intensity is created hence centre of ring pattern is dark.

Q: If we now use transmitted light instead of reflected light, will there be any change in the center spot? Explain.

50.91 cm. Error rate = ((50.91-50)/50)*100% = 1.82 % Accuracy rate = (100 -1.82)% = 98.18 % The bright lines indicate constructive interference and the dark lines indicate destructive interference. Also, the dark fringes residing on any side of the zero-order fringe is caused by destructive interference. The center of the ring dark in Newton's Rings experiment with reflected light is dark because at the point of contact the path difference is zero but one of the interfering ray is reflected so the effective path difference becomes λ/2 thus the condition of minimum intensity is created hence center of ring pattern is dark. It all depend on what the material absorbs and what it reflects. If you use a very high quality glass mirror you seemingly see no difference but as you add more and more mirrors for reflection. So the answer is both yes and no. Reason for it being No is: The light being reflected is simply the light from the source itself and has not impact on the light. Reason for it being yes is: Depending on the material that you are using to "reflect" the light. All material actually absorb light and then "reflects" the remaining light and then you would see a color difference.

Q: As like this experiment, thin film interference is occurred in the thin film of soapy water in a bubble, as a result it looks multicolored. Explain why and how a soap bubble looks multi colored.

When light waves hit a bubble, some of them bounce straight back off the outer part of the soap film. Others carry on through but then bounce off the inner part of the film. So one set of light rays shine into a soap bubble, but two sets of rays come back out again. When they emerge, the waves that bounce off the inner film have traveled a tiny bit further than the waves that bounced off the outer film. So we have two sets of light waves that are now slightly out of step. Like two sets of ripples on a pond, these
waves start merging. Just like on a pond, some add together and some cancel out. The overall effect is that some of the colors in the original white light disappear altogether, leaving other colors behind. These are the colors you see in soap bubbles.

Q: In Newton's ring experiment why the glass plate (in our given apparatus it is circular) is place at 45^0?

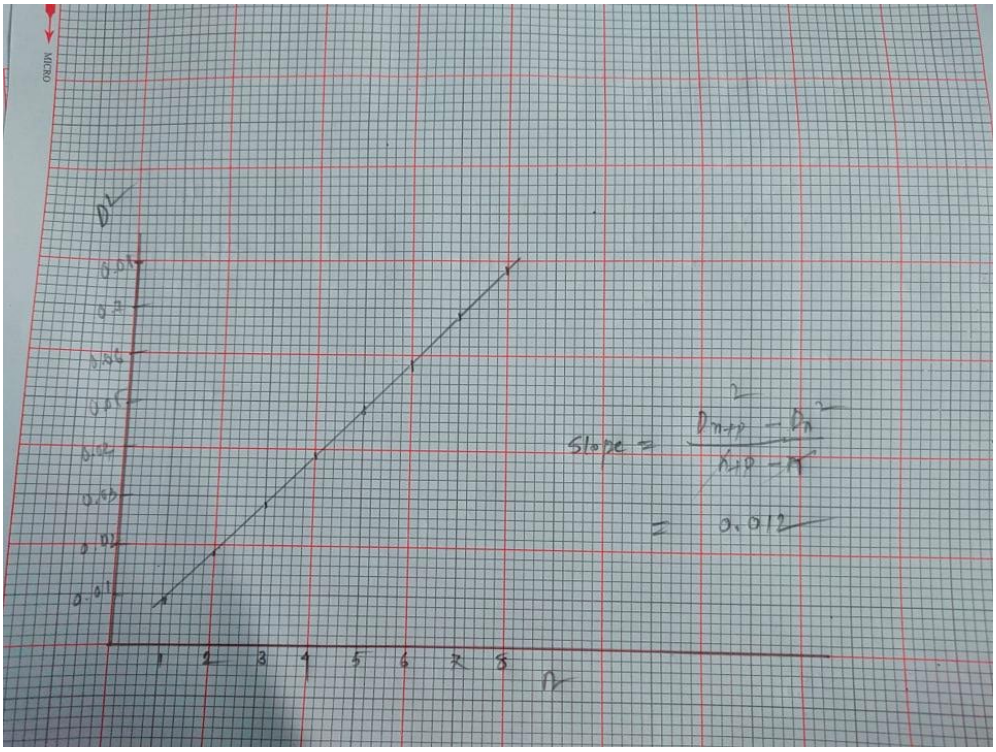
In Newton's ring experiment we set angle of reflection glass Plate is 45° because light source of (sodium light source) is placed at 90°angle between light source and microscope so set glass plate at 45° angle which reflects 90° horizontal to 90° vertical and we observe the rings in microscope.

Q: Why are the fringes circular?

Newton's rings are circular because of the path difference between the reflected ray and incident ray depends upon the thickness of the air gap between lens and the base. As the lens is symmetric along its axis, the thickness is constant along the circumference of a ring of a given radius.

Q: Why should a lens of large radius of curvature is used in this experiment?

Because if we use a lens of small radius of curvature rings will be of smaller diameter. Then there is a chance of error while taking the reading.



D²
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1 2 3 4 5 6 7 8
n
Slope = $\frac{D_{n+p}^2 - D_n^2}{n+p - n}$
= 0.012