Date : 3-07-2021

Expt. No : 6

Page No :

6. NEWTON'S RING EXPERIMENT

AIM:

To determine the Radius of curvature of a plano convex lens.

APPARATUS:

Sodium lamp
Newton's Ring apparatus which includes
- collimator
- Glassplate
- Plano convex lens
- Mirror
- Telescope
- Spherometer.

THEORY:

A plano convex lens is placed with its convex surface on the mirror, so as to enclose a thin film of air of varying thickness between the lens and mirror.

Monochromatic light (i.e Sodium lamp) is focused on a glass plate which is placed at an angle of 45° to vertical. In between the monochromatic light and glass plate, a collimator is placed so that light rays from different angles are converted into parallel rays as shown in Fig-1.

Working principle :-

(Working) When the parallel rays hit the glass plate,

Teacher's Signature :

Date : ....

Expt. No : ....

Page No : ....

Some of the rays get transmitted and some rays reflected down (towards the plano convex lens).

The reflected light first pass through the lens and then the air film and then it will directly reflected by the mirror. This reflected light goes back and hit the glass plate.

Again some of the light rays reflected back to source and some get transmitted. This transmitted light can be observed through viewing piece (i.e microscope).

As we go away from the centre, the path difference between incident and reflected rays will different. This results in phase difference between incident and reflected rays which cause interference.

- When both rays are in same phase there will be constructive interference (they both add up).
- When both rays are in out phase there will be destructive interference (they cancel each other)

And we can see dark and bright regions called Newton's rings.

As the lens is in constact with the mirror and thickness of air film at the center is zero, the center will be dark. By stoke's law, the path difference takes place due to reflection at the lower surface of air film as the light ray passes from rarer to denser medium. When we move away from center, the thickness of air film gradually increases.

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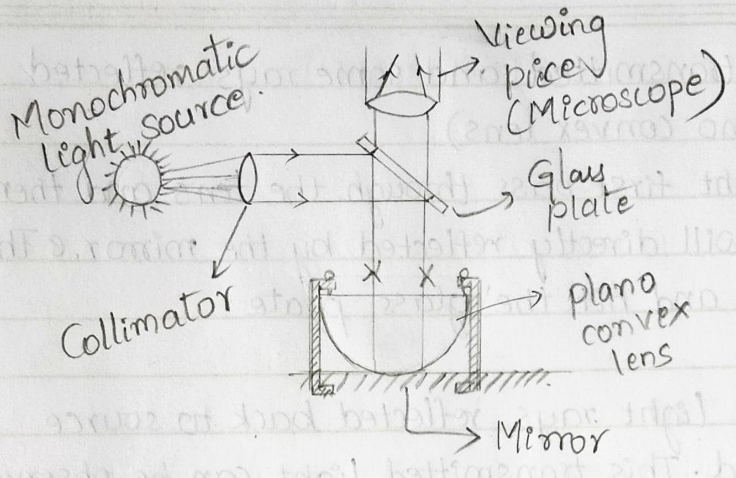

Fig 1. Experimental Setup

Fig 2. Newton's rings

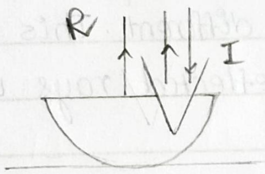

Fig 3.

Thus the fringes produced are concentric circles as shown in Fig-2.

The fringes are circular because of the fact that air film is symmetric about point of contact (center). The locus of all points at same thickness is a circle.

Let R be the radius of curvature of plano convex lens
D_n is the diameter of n^{th} dark fringe (ring)
λ is the wavelength of monochromatic light source then,

$D_n^2 = 4nR\lambda$ —① Here there are chances of having error

Let m be the another dark ring

then $D_m^2 = 4mR\lambda$ —②

From ① & ② $\boxed{R = \dfrac{D_n^2 - D_m^2}{4(n-m)\lambda}}$

Here, the formula involves difference of squares of diameter of two rings and is independent of thickness of air film at center 'O'. Thus the error is reduced.

PROCEDURE :

1. First find the least count of microscopic scale and place the apparatus in their appropriate position as shown in Fig-1.
2. Make sure to clean the surface of mirror and plano-convex lens and put them in correct position. So that error will be minimized
3. Now switch on the sodium lamp and check whether the light rays are incidenting parallel to the glass plate or not.

OBSERVATION TABLE :

Ring no.	Microscope reading		Diameter (cm)	Diameter square (cm^2)
	left (a) cm	Right (b) cm	a-b=c (cm)	c^2 (cm^2)
18	1.785	1.193	0.592	0.3504
16	1.780	1.210	0.57	0.3249
14	1.746	1.228	0.518	0.2683
12	1.727	1.248	0.479	0.2294
10	1.703	1.27	0.433	0.1874
8	1.686	1.304	0.382	0.1459
6	1.652	1.322	0.33	0.1089
4	1.619	1.369	0.25	0.0625
2	1.573	1.41	0.163	0.0265

CALCULATIONS : $\lambda = 5893 A^\circ$

$n=18,\ m=2$

$$R_1 = \frac{(D_{18}^2 - D_2^2)\times 10^{-4}}{4(18-2)\times 5893\times 10^{-10}}$$

$$= \frac{0.3239\times 10^{6}}{4\times 16\times 5893}$$

$= 0.8588$ m

$n=16,\ m=4$

$$R_2 = \frac{(D_{16}^2 - D_4^2)\times 10^{-4}}{4\times(16-4)\times 5893\times 10^{-10}}$$

$$= \frac{(0.3249-0.0625)\times 10^{-4}}{4\times 12\times 5893\times 10^{-10}}$$

$= 0.9276$ m

Graph for Record book

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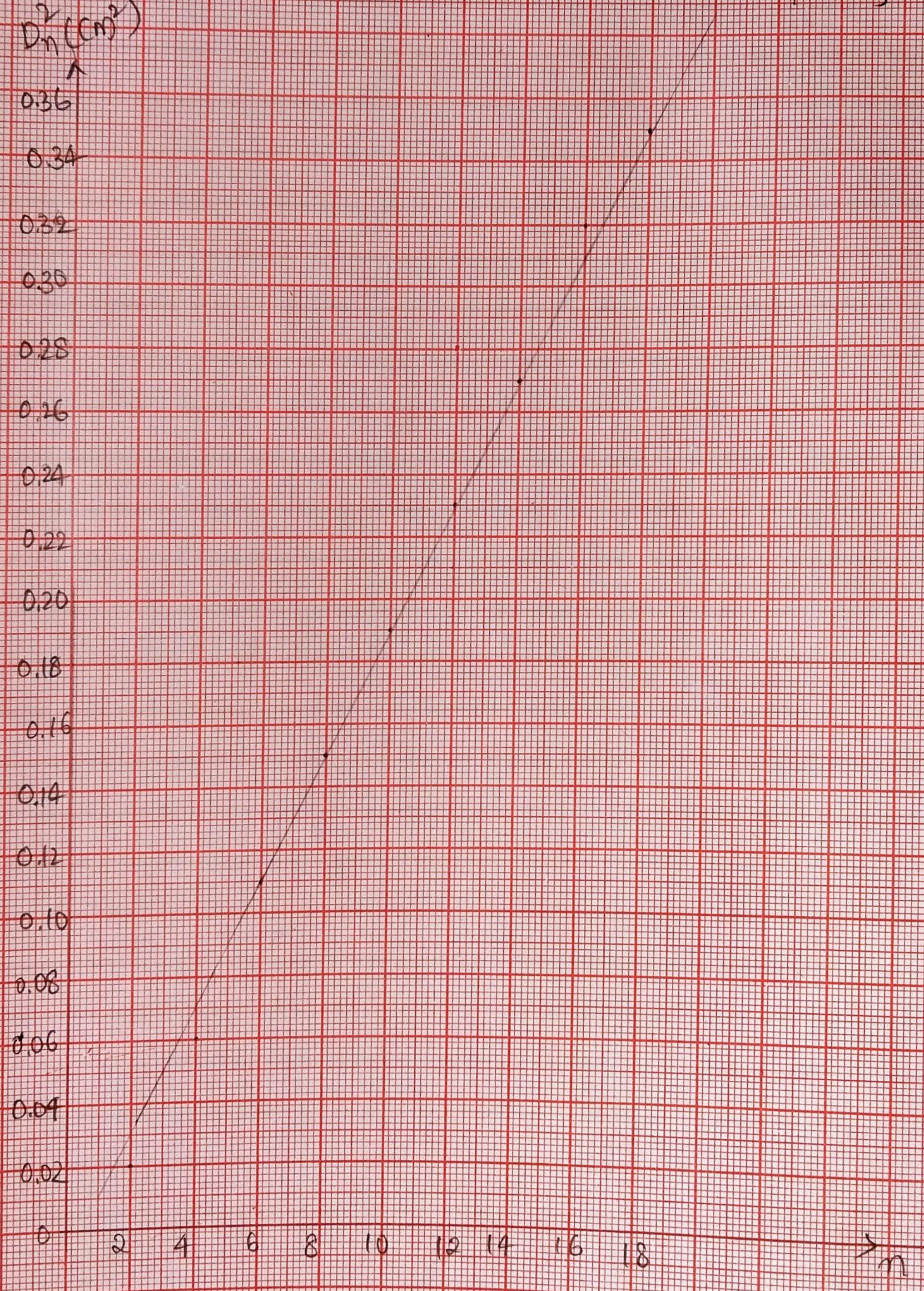
Scale:
X-axis, 1cm = 2units
Y-axis, 1cm = 0.02 unit



$n=14, m=6$

$$R_3 = \frac{(D_{14}^2 - D_6^2)\times10^{-4}}{4\times(14-6)\times5893\times10^{-10}}$$

$$= \frac{(0.2683-0.1089)\times10^6}{4\times8\times5893}$$

$$= 0.84528\ m$$

$n=12, m=8$

$$R_4 = \frac{(D_{12}^2 - D_8^2)\times10^{-4}}{4\times(12-8)\times5893\times10^{-10}}$$

$$= \frac{(0.2294-0.1459)\times10^6}{4\times4\times5893}$$

$$= 0.88558\ m$$

$n=10, m=2$

$$R_5 = \frac{(D_{10}^2 - D_2^2)\times10^{-4}}{4\times(10-2)\times5893\times10^{-10}}$$

$$= \frac{(0.1874-0.0265)\times10^6}{4\times8\times5893}$$

$$= 0.85324\ m$$

$$R_{avg} = \frac{R_1+R_2+R_3+R_4+R_5}{5}$$

$$= 0.8741\ m$$

$$= 87.41\ cm$$

From graph,

$$slope = \frac{y_2-y_1}{x_2-x_1} = \frac{(0.23-0.19)\times10^{-4}}{12-10}$$

$$= 0.02\times10^{-4}$$

$$slope = 4R\lambda$$

$$R = \frac{slope}{4\lambda} = \frac{0.02\times10^{-4}}{4\times5893\times10^{-10}}$$

$$= 0.8484\ m$$

$$R = 84.84\ cm$$

$$\text{Final } R = \frac{87.41 + 84.84}{2}$$

$$R = \underline{86.125 \text{ cm}}$$

Date : ....

Expt. No : .... Page No : ....

4. Then adjust the microscope position such that it lies exactly vertical above the center of lens and adjust the focal length of microscope to observe dark and bright rings clearly.
5. We have to adjust the microscope till the point of intersection of crosswire coincides with center and one of the vertical-cross wire is perpendicular to horizontal scale.
6. With the help of micrometer screw, move the microscope to the left such that vertical cross wire lies tangential to one of the extreme ends of the 18th dark fringe and note the corresponding readings.
7. By sliding the microscope backward, note the readings corresponding to extreme ends of 16th, 14th, 12th, 10th, ... 2th dark ring respectively.
8. Now, move the microscope to right, to note the readings at other extreme of the diameter of dark rings.
9. Finally remove the plano convex lens and find the radius of curvature of it by using (spectometer) spherometer.

RESULT:

Radius of curvature from table calculations = 87.41 cm

Radius of curvature from graph = 84.84 cm

CONCLUSION:

Radius of curvature of a plano convex lens is 86.125 cm

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