20CSE1030

Newton's Rings Experiment

Aim: To determine the radius of curvature of the plano convex lens through newtons' ring experiment.

Operators:
1. Newton's rings apparatus with reflector.
2. Sodium light source.
3. Bridge type microscope SPA13
4. Wooden block
5. Plano Convex lens with plane glass plate.

Theory:

A plano convex lens is placed with its convex surface on the optically plane glass plate so as to enclose a thin film of air of varying thickness between the lens and the plates. light from an extended monochromatic source (ie sodium lamp) of light is converted into a parallel beam of light by using a convex lens L of short focal length and made to fall on an optically plane glass plate inclined at the angle of 45° to the vertical, where it gets reflected on to the plano-convex lens L as shown in fig. 1.

Interference takes place between the rays of light reflected from the upper and the lower surfaces of the wedge shaped air film enclosed between lens L and glass plate P and circular interference fringes (alternate dark & bright) called Newton's rings are produced as shown in fig 2.

The center will be dark because at the center, lens in in contact with the glass plate and thickness of air film at the centre is zero. By stoke's law, a phase change of (or path difference of fig 2) takes place due to reflection at the lower surfaces of the air film (fig 3) as the ray of light passes from rarer to denser medium. As we proceed outwards from the center, the thickness of the air film gradually increases being the same all along the circle with the center at the point of contact. Thus the fringes produced are concentric circles and localized in the air film. The fringes can be viewed by means of a low power traveling microscope 'M' as shown in fig 1

The fringes are circular due to the fact that air film is symmetrical about the point of contact. The locus of all the points at same thickness is a circle. i.e. all the points where the air film has a given thickness lie on a circle whose center is at 'O'.

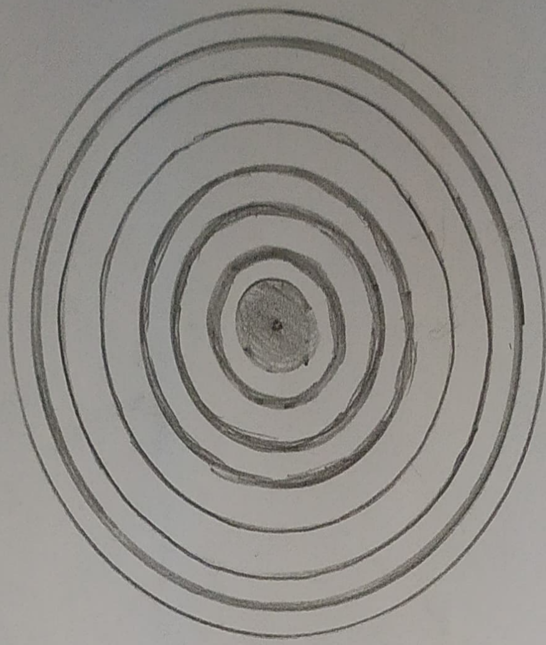
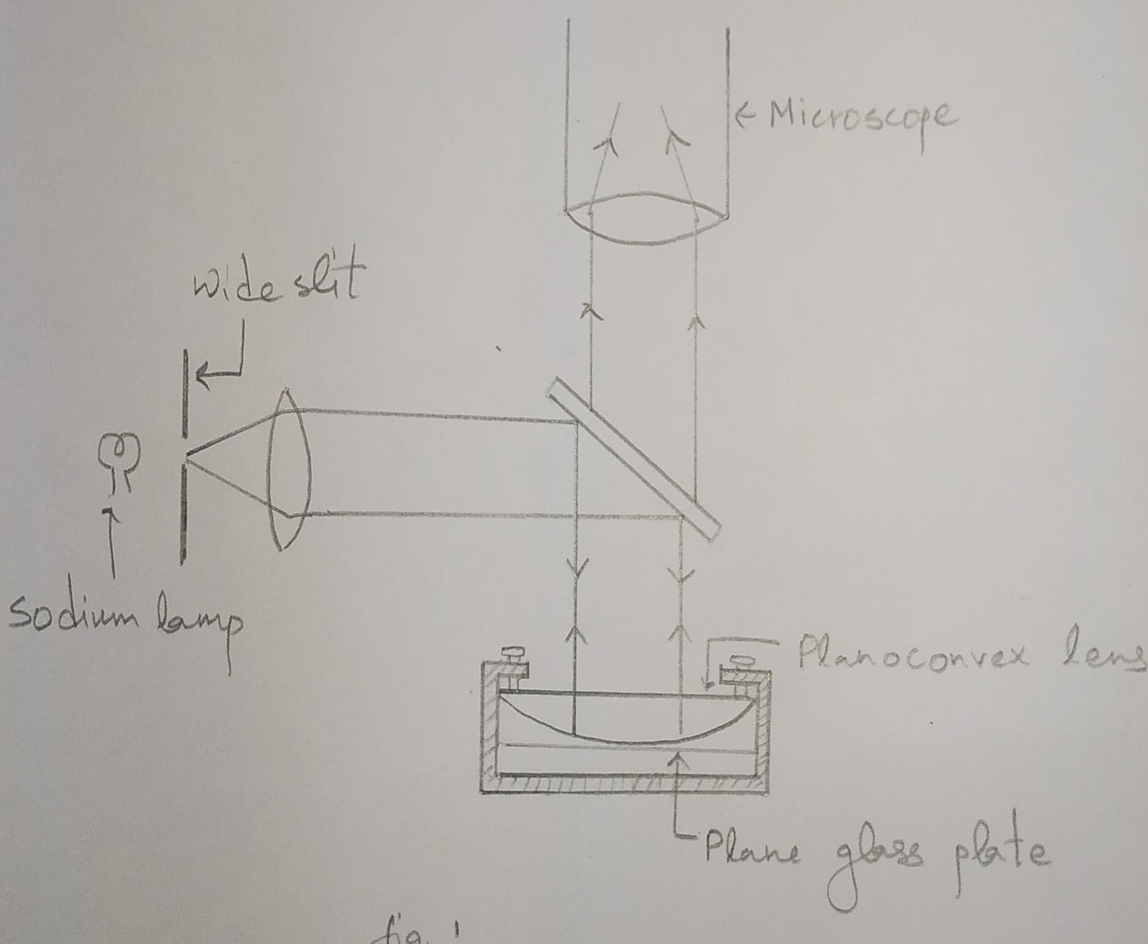


fig 2



Microscope
wide slit
sodium lamp
Planoconvex lens
Plane glass plate

fig 1

Let 'R' be the radius of curvature of the surface of plano-convex lens in contact with the glass plate P.

$D_n \Rightarrow$ Diameter of the n^{th} dark ring

$\lambda \Rightarrow$ wavelength of monochromatic source of light source used

then $D_n^2 = 4nR\lambda$

It may be pointed out that surfaces of the lens and the plate may not be clean and the lens may not be perfect contact with the glass plate at the center. Then the center will not be dark. To eliminate the error due to this problem -

The diameter of any two dark rings ~~sy~~ say, n & m may be determined.

Therefore

$$D_n^2 = 4nR\lambda \quad \text{——— (1)}$$

$$D_m^2 = 4mR\lambda \quad \text{——— (2)}$$

from equation (1) & (2) we get

$$\lambda = \frac{D_n^2 - D_m^2}{4(n-m)R} \quad \text{——— (3)}$$

Since, this formula involves the difference of the square of the diameters of two rings and is independent of the thickness of the air film at the point of contact 'O', the above error is minimized.

If the measurements are made on bright rings of the diameter of 'n' bright ring is given by

$$D_n^2 = 2(2n+1)R$$

Therefore diameter of the ring depends upon the wavelength of light used.

If white light is used in place of monochromatic light, a few coloured rings are observed. Each color gives rise to its own system of rings. These colored rings soon superimpose and overlap thereby resulting in almost uniform illimination after a few rings.

If a plane mirror is placed in place of glass plate below the plano-convex lens, a uniform illumination is observed as whole of light gets reflected from the mirror.

Procedure

1. Find the least count of microscope scale.

2. Clean the surface of glass plate, and the Plano Convex lens L. Put them in position as shown in fig 1 in front of the sodium lamp.

3. Switch on the sodium lamp and see that only parallel beam of light coming from the convex lens falls on the glass plate.

4. Adjust the position of the microscope till the point of intersection of the cross-wires coincides with the center of the ring system and one of the vertical cross-wires is perpendicular to the horizontal scale.

5. Adjust the position of the microscope so that it lies vertically above the center of the lens. Focus the microscope so that alternate dark and bright rings are clearly visible.

6. Move the microscope to the left with the help of micrometer screw so that the vertical cross wire lies tangentially at one of the extreme ends of the 20^{th} dark ring.

7. Note the reading of the micrometer scale of the microscope.

8. Slide the microscope backward with the help of micrometer screw and go on noting the readings when the cross wire lies tangential at the extreme ends of ~~hore~~ horizontal diameter of 16^{th}, 12^{th}, 8^{th} and 4^{th} dark rings resp.

9. Continue sliding the microscope to the right and note the readings when the vertical cross wires lies tangentially at the other extreme end of the diameter of 4^{th} 8^{th} 16^{th} 20^{th} dark rings resp.

Date
Page

10. Now slide the microscope backwards and again note down the reading corresponding to the same rings on the right and then on the left to the center of the ring system.

Observations:

Least count = 0.001 cm

Pitch of micrometer scale = 0.1cm.

Ring No.	left (a)	Right (b)	a − b = c (diameter)	Diameter^2
18	1.785	1.193	0.592	0.3505
16	1.780	1.210	0.570	0.325
14	1.748	1.228	0.518	0.268
12	1.727	1.248	0.479	0.229
10	1.703	1.270	0.433	0.187
8	1.686	1.304	0.382	0.146
6	1.652	1.322	0.330	0.109
4	1.619	1.369	0.250	0.062
2	1.573	1.410	0.163	0.026

Calculations.

for $n = 18$ and $m = 2$

$$R = \frac{D_{18}^2 - D_2^2}{4 \times (18-2) \times 589 \times 10^{-9}}$$

$$= \frac{0.3505 - 0.026}{4 \times 16 \times 589 \times 10^{-9}}$$

$R_1 = 86.08$ cm

for $n = 16$ and $m = 2$

$$R = \frac{D_{16}^2 - D_2^2}{4 \times (16-2) \times \lambda}$$

$$= \frac{0.325 - 0.026}{4 \times 14 \times 589 \times 10^{-9}}$$

$R_2 = 90.65$cm

for $n = 18$ $m = 4$

$$R = \frac{D_{18}^2 - D_4^2}{4\times(18-4)\times 589\times10^{-9}}$$

$$= \frac{0.3505 - 0.062}{4\times14\times589\times10^{-9}}$$

$R_3 = 87.47$ cm

for $n = 16$ $m = 4$

$$R = \frac{D_{16}^2 - D_4^2}{4\times(16-4)\times 7}$$

$$= \frac{0.325 - 0.062}{4\times12\times589\times10^{-9}}$$

$R_4 = 93.02$ cm

for $n = 18$ & $m = 10$

$$R = \frac{D_{18}^2 - D_{10}^2}{4\times(18-10)\times589\times10^{-9}}$$

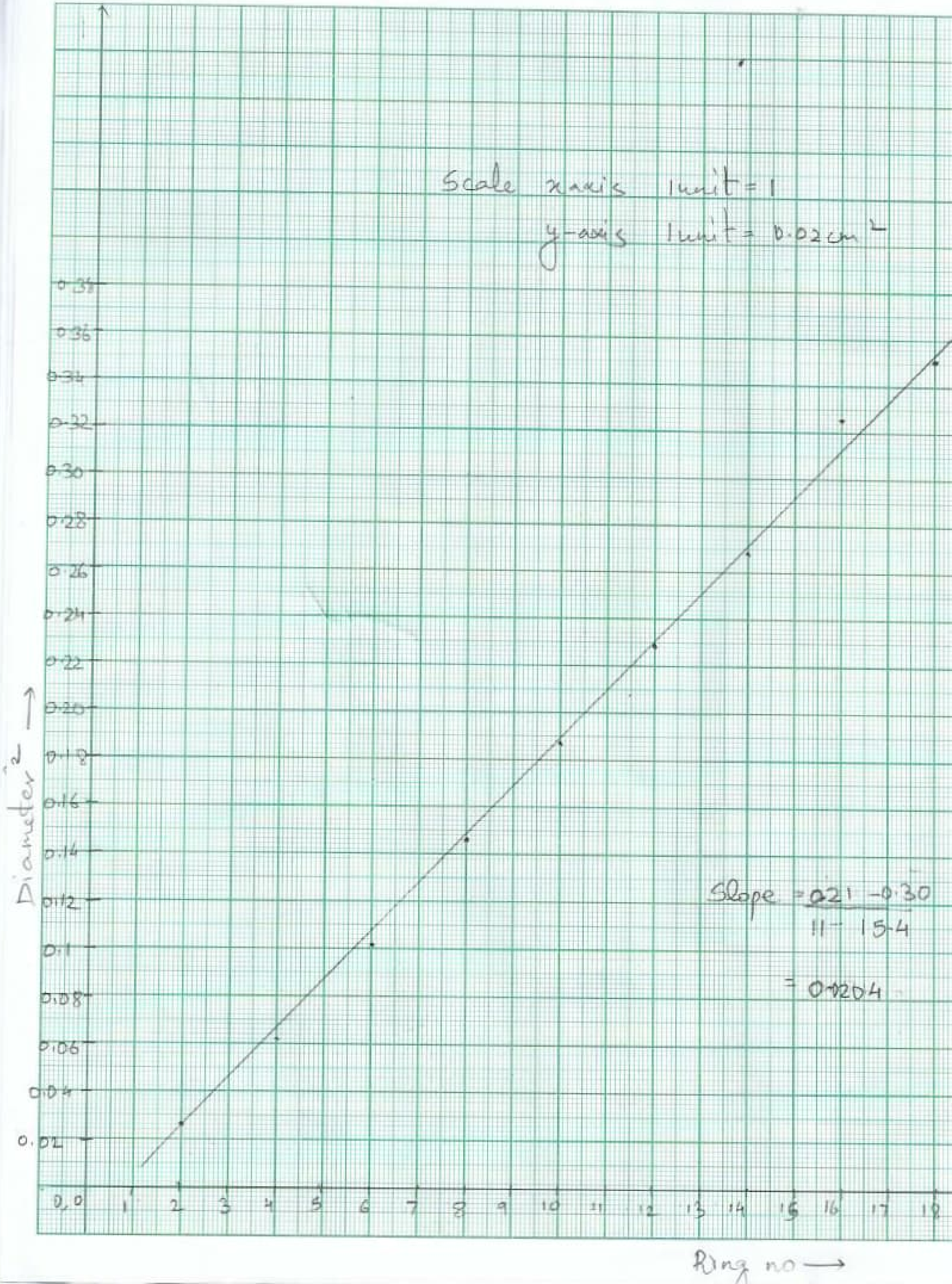
$$= \frac{0.3505 - 0.187}{4\times8\times589\times10^{-9}}$$

$R_5 = 86.75$ cm

Average $R = \frac{R_1+R_2+R_3+R_4+R_5}{5}$

$$= \frac{86.08+90.65+87.47+93.02+86.75}{5}$$

$R_{avg} = 88.79$ cm.


Scale x-axis 1unit = 1
y-axis 1unit = 0.02cm²
Diameter² →
Ring no →
Slope = (0.21 - 0.30)/(11 - 15.4)
= 0.0204
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.20
0.22
0.24
0.26
0.28
0.30
0.32
0.34
0.36
0.38
0,0
1
2
3
4
5
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7
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15
16
17
18

slope of graph D^2 v/s ring no. $= 0.0204 \ cm^2$

from eqn $D_n^2 = (4R\lambda)\,n$

slope $= 4R\lambda$

$$R = \frac{slope}{4\lambda}$$

$$= \frac{0.0204 \times 10^{-2}}{4 \times 589 \times 10^{-9}}$$

$R_n = 86.59 \ cm$

Radius of curvature of lens from table = 88.79 cm

Radius of curvature of lens from slope = 86.59 cm.

$$R_{mean} = \frac{88.79 + 86.59}{2}$$

$$R_{mean} = 87.68 \text{ cm}$$

Conclusion:

- The radius of curvature of plano convex lens as determined by Newtons ring expt is found to be 87.68cm
- On the microsope alternating circular bright and dark fringes were observed which suggest wave nature of light showing property of interference.
- The linear nature of graph suggests that diameter of n^{th} ring is ~~pro~~directly proportional to the sqrt of ring number.

As we go farther from center the ring width get smaller.

Result:

The radius of curvature of plano convex lens is 87.68cm.