THE NEOTIA UNIVERSITY

WORK INSTRUCTION

1.0 EXPERIMENT NO: BO/03
2.0 NAME OF EXPERIMENT: Newton's Ring
**3.0 0BJECTIVE:** Determination of Wavelength of Light by Newton's Ring method
4.0 THEORITICAL BACKGROUND
   (A) Interference:

Interference is caused by coherent waves interacting with each other as they intersect, causing waves to either add together (constructive interference) or cancel (destructive interference).
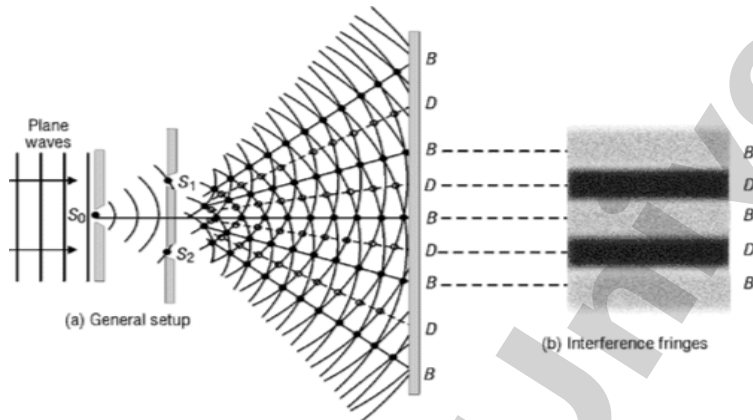
(a) General setup   (b) Interference fringes

- ***Constructive interference*** is the point of intersection between two light waves where their interaction combine together to give rise to a larger wave (Amplified), but the wavelength stays the same. The resultant of constructive interference is a bright band of light.

- ***Destructive interference*** is the point of intersection between two light waves where their interaction will cancel each other out to give a null point with zero amplitude i.e. dark band of light.
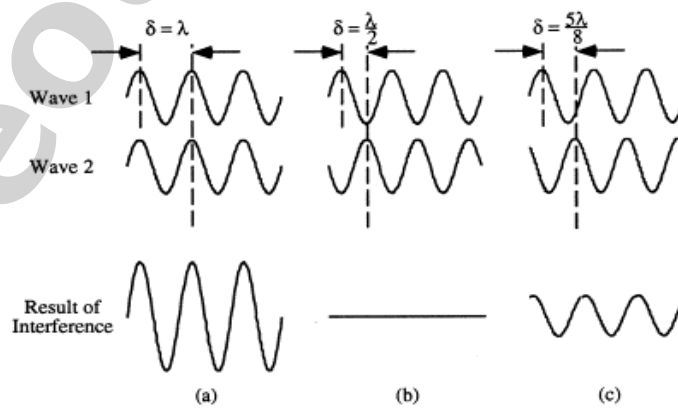
In general, ordinary light waves are usually *in-coherent* because they produce well-phased light for only about 10^{-8} sec and also have random change in relative phase. Thus we can not see the usually sustained interference pattern with ordinary light. But coherent sources such as LASER, Na-Vapour lamp can produce sustained interference.

(B) Newton's Ring

The phenomenon of Newton's rings is an illustration of the interference of light waves reflected from the opposite surfaces of a thin film of variable thickness. The two interfering beams, derived from a monochromatic source satisfy the coherence condition for interference.

Ring shaped fringes are produced by the air film existing between a convex surface of a long focus plano-convex lens and a plane of glass plate.
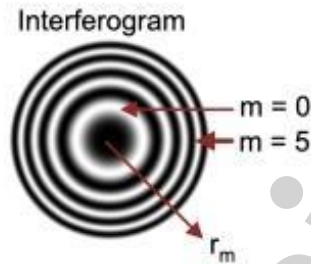

Figure 3.

(C) Calculation of diameters of Newtons Ring:

When a plano-convex lens (L) of long focal length is placed on a plane glass plate (G) , a thin film of air I enclosed between the lower surface of the lens and upper surface of the glass plate.(see fig 4). The thickness of the air film is very small at the point of contact and gradually increases from the center outwards. The fringes produced are concentric circles. With monochromatic light, bright and dark circular fringes are produced in the air film(see fig 3). *When viewed with the white light, the fringes are colored.*

A horizontal beam of light falls on the glass plate B at an angle of 45^0. The plate B reflects a part of incident light towards the air film enclosed by the lens L and plate G. T the air film is viewed with a microscope. Interference takes place and dark and bright circular fringes are produced. This is due to the interference between the light reflected at the lower surface of the lens and the upper surface of the plate G.
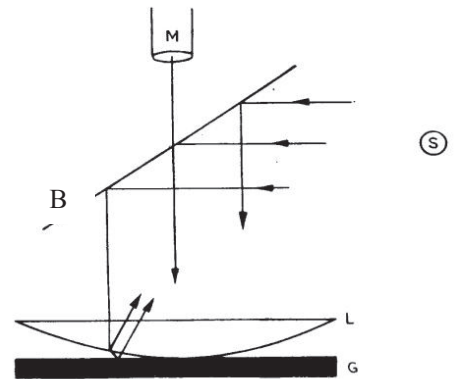
For the *normal incidence* the optical path difference Between the two waves is nearly 2μt, where 'μ' is the refractive index of the film and 't' is the thickness of the air film.

Figure 4.

Here an extra phase difference π occurs for the ray which got reflected from upper surface of the plate G because the incident beam in this reflection goes from a rarer medium to a denser medium. Thus the conditions for constructive and destructive interference are (using μ = 1 for air)

$2t = n\,\square$ for minima; n = 0, 1, 2, 3… … … …**(1)**

and $2t = \left(n + \dfrac{1}{2}\right)\lambda$ for maxima; ; m = 0,1,2,3… … …**(2)**

Then the air film enclosed between the spherical surface of R and a plane surface glass plate, gives circular rings such that (see fig 3)

$$r_n{}^2 = (2R-t)t$$

where r_n is the radius of the nth order dark ring .
(Note: The dark ring is the nth dark ring excluding the central dark spot).

Now R is the order of 100 cm and t is at most 1 cm. Therefore R>>t. Hence (neglecting the t^2 term), giving

$$2t \approx \frac{r_n^2}{R}$$

Putting the value of " 2 t" in eq(1) gives $n\lambda = \frac{r_n^2}{R}$

With the help of a traveling microscope we can measure the diameter of the nth ring order dark ring (D_n)
Then $r_n = D_{n/2}$ and hence,

$$D_n^2 = 4Rn\lambda \tag{1}$$

we can also measure the diameter of the mth ring order dark ring and would obtain

$$D_{m+n}^2 = 4R(m+n)\lambda \tag{2}$$

Using (1) and (2) we obtain

$$\lambda = \frac{D(m+n)^2 - D_n^2}{4R(m)}$$

So if we know the R(radius of curvature of the lens), we can calculate wavelength λ and vice-versa. Also we can determine refractive index of any unknown liquid.
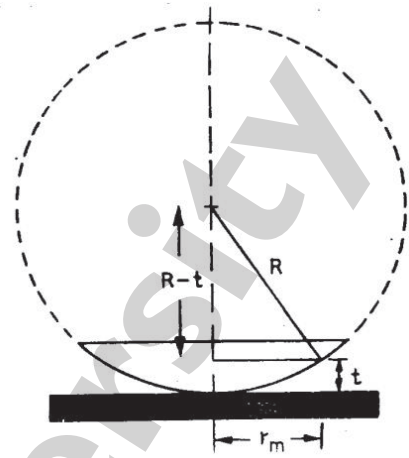
Figure 3.

5.0 PRINCIPLE: When a parallel beam of monochromatic light of wavelength λ is made incident on the wedge shaped air- film (between glass) plate and convex surface of a plan convex lens for each incident ray we get two reflected rays shown as in figure below. These two rays will interfere and will produce alternate bright and dark concentric rings, the central spot is dark.
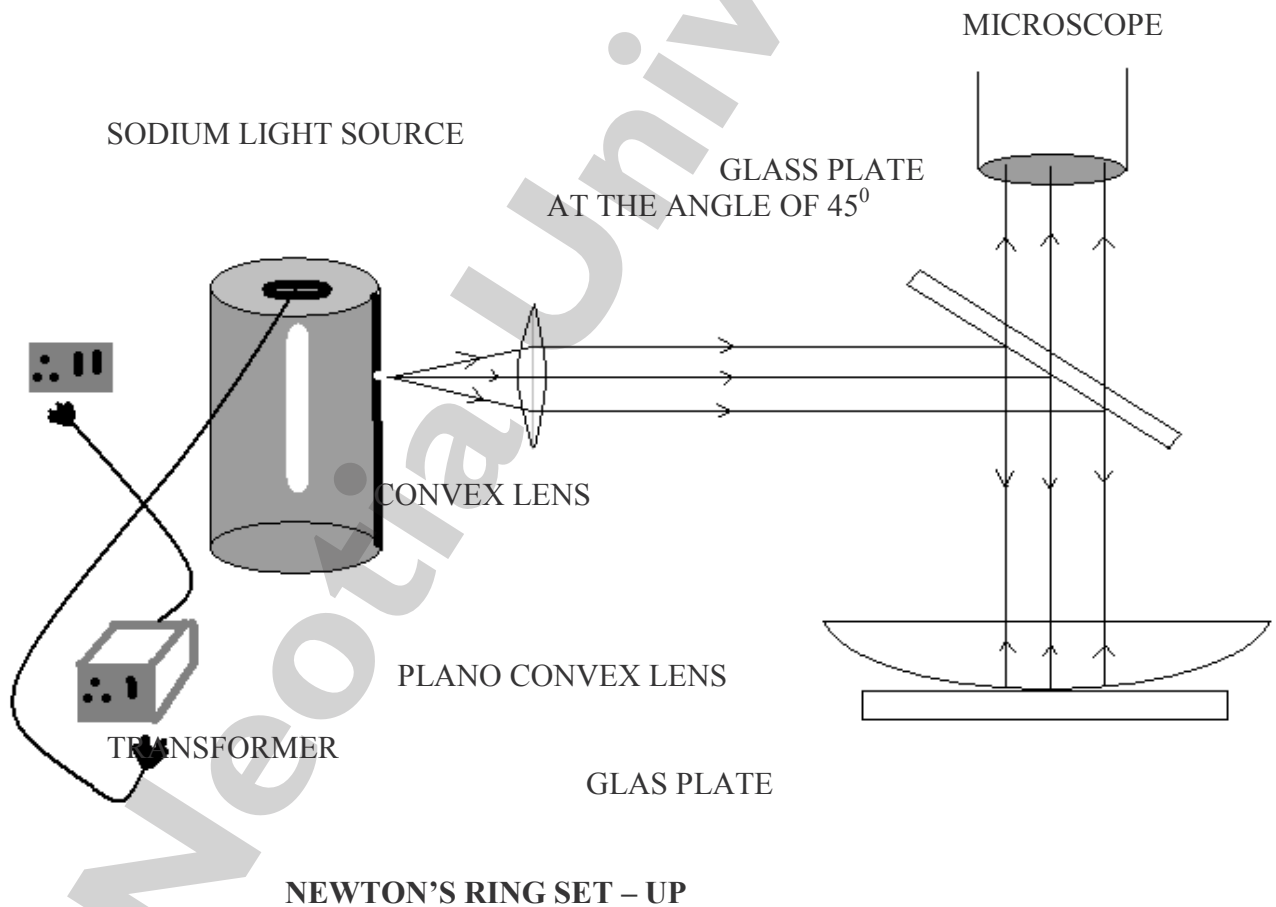
If D_m and D_{m+n} be the diameters of mth and $(m + n)^{th}$ bright or dark rings, then the wavelength $λ$ of the incident monochromatic light is:

$$\lambda = \frac{D_{m+n}^{2} - D_n^{2}}{4Rm}$$

D_m= diameter of the mth bright/dark ring
D_{m+n}=diameter of $(m + n)^{th}$ bright/dark ring
R= radius of curvature of convex surface of the Plano convex lens.

MICROSCOPE

SODIUM LIGHT SOURCE

GLASS PLATE
AT THE ANGLE OF 45^0

CONVEX LENS

PLANO CONVEX LENS

TRANSFORMER

GLAS PLATE

NEWTON'S RING SET – UP

6.0   TOOLS/APPARATUS REQUIRED:
- Microscope
- Sodium Lamp
- Convex Lens
- A Glass Plate
- Plano Convex Lens

7.0 PROCEDURE: (Don't write the procedure in the worksheet)

- Determine the least count of the circular scale of the travelling microscope.

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- Switch on the monochromatic light source. This sends a parallel beam of light. This beam of light gets reflected by the plate falls on the lens.

↓

- Look down vertically from above the lens and see whether the center is well illuminated. On looking through the microscope, a spot with rings around it can be seen on properly focusing the microscope.

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- Once good rings are in focus, rotate the eyepiece such that out of the two perpendicular cross wires, one has its length parallel to the direction of travel of the microscope.

↓

- Now move the microscope to focus on a ring (say, the 20th order dark ring on your left hand side).

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- Set the crosswire tangential to the ring as shown in fig 2. Note down the microscope readings (both main scale and circular scale).
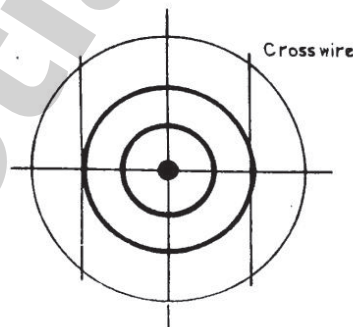

Figure 2.

- Move the microscope to make the crosswire tangential to the next ring nearer to the center(say 19th) and note the reading. Continue with this purpose till you reach to the 20th ring (say) on your right hand side. *To avoid the backlash error circular scale should be rotated in one direction*.

↓

- Calculate diameters of each ring.

↓

- Plot a graph with 'n' *(order number)* along abscissa (x - axis) and D_n^2 along vertices (y – axis).

↓

- Find the slope of the curve from the graph and find the wavelength of the light.

8.0 TABULATION:

TABLE-1
To determine the least count (*l.c.*) of the travelling microscope
Pitch of the travelling microscope is defined as the distance travelled by the circular scale for a complete rotation.

Pitch of the travelling microscope p (mm)	No. of division of the circular scale n	Least count (*l.c.*) = p/n (mm)

TABLE-2

To measure the diameters of Newton's ring

No. of Rings (n)	Microscope reading						Diameter $D_n =$ (x - y) (cm.)	D_n^2 in (cm^2)
	Left of central point (x)			Right of central point (y)				
	Main. Scale Reading (mm) (L)	Circular scale reading (K)	Total (mm) $x=$ $L + K \times l.c.$	Main. Scale Reading (mm) (L)	Circular scale reading (K)	Total (mm) $y=$ $L + K \times l.c.$		

Graph and Result

From the data of the Table – 2 plot a graph with n along abscissa (x - axis) and D_n^2 along vertices (y – axis). Determine the values of n and D_n^2 from the graph. Therefrom calculate the value of the wavelength of light as illustrated in Table -3.

TABLE-3
Determination of wavelength of monochromatic light

Value of R (cm.) (Supplied)	Value of D_n^2 or $(D_{m+n}^2 - D_n^2)$ from graph (cm^2)	m from graph	Value of λ $= \dfrac{D_{m+n}^2 - D_n^2}{4Rm}$ in Å
64			

9.0 COMPUTATION OF PERCENTAGE ERROR:

We have the formula for the Determination of wavelength of monochromatic light by Newton's ring

as
$$\lambda = \frac{D_{m+n}^{\ 2} - D_n^{\ 2}}{4Rm}.$$

Where, R is the radius of curvature of the lens.
Taking 'ln' in both sides we get,

$$\ln \lambda = 2\ln D_m - \ln 4 - \ln R - \ln m$$

Differentiating we get for maximum proportional error,

$$\frac{\delta \lambda}{\lambda} = \frac{\delta(D_{m+n}^{\ 2} - D_n^{\ 2})}{D_{m+n}^{\ 2} - D_n^{\ 2}} + \frac{\delta m}{m}$$

(Rest of the term will be zero as R is constant and differentiation of this term will vanish)

$\delta(D_{m+n}^{\ 2} - D_n^{\ 2})$ = error in measuring $(D_{m+n}^{\ 2} - D_n^{\ 2})$

$\qquad\qquad$ = 8 x minimum division of the scale (*l.c.*);

$(D_{m+n}^{\ 2} - D_n^{\ 2}$ is measured by taking the difference between the two readings of a scale provided with a vernier, the maximum error in measuring each of these quantities is twice the vernier constant i.e. $2 \times l.c.$. the error in Dn^2 or $D_{m+n}^{\ 2}$ is, therefore $4 \times l.c$. The error in obtaining $D_{m+n}^{\ 2} - D_n^{\ 2}$ is $8 \times l.c.$)

δm = error in measuring m

$\qquad$ = 1 (because probability of making error is in one side)

Putting suitable values calculate the value of proportional error.

Hence, the percentage error is $\quad (\frac{\partial \lambda}{\lambda} \times 100)\,\%$
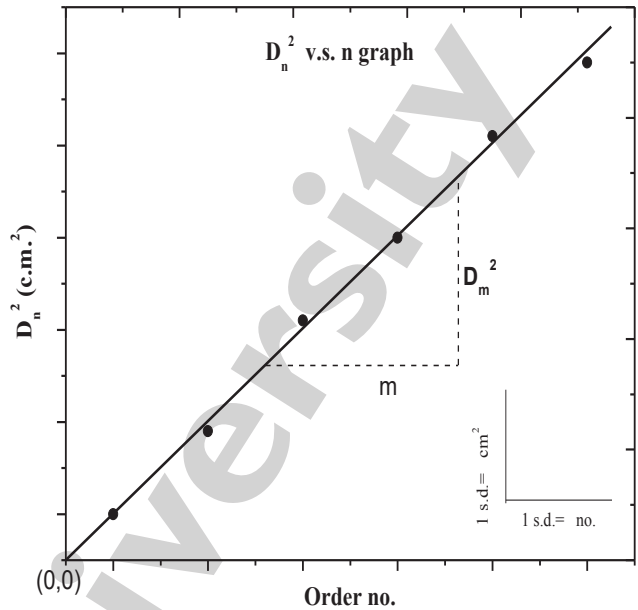
9.0 DISCUSSION :

You have to write all the difficulties you faced during the experiment and their remedies. Also you have to mention some way out that one should adopt during the practical to have a better result.

References
1) OPTICS - Ghatak
2) OPTICS – K. G. Majumdar
3) ADVANCED PRACTICAL PHYSICS- Ghosh & Majumdar