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Y.M.S

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Young`s Modulus by Using Bending of Beam

Aim:- To determine the Young`s modulus of the material of a given beam by using bending of Beam

Setup Contains:-

1. Bending of Beam Accessories.
2. Galvanometer 30-0-30.
3. Power Supply (0-5)V, 250 mA.
4. DCC Wire.
5. Slotted Weight 500gmx6.
6. Screw Gauge & Vernier Caliper.
7. Inch tape.

Formula Used:-

The young`s modulus for the material of a given beam,

$$Y = MgL^3 / 4bd^3\delta$$

Where,

M= Load suspended from the beam.

g = Acceleration due to gravity.

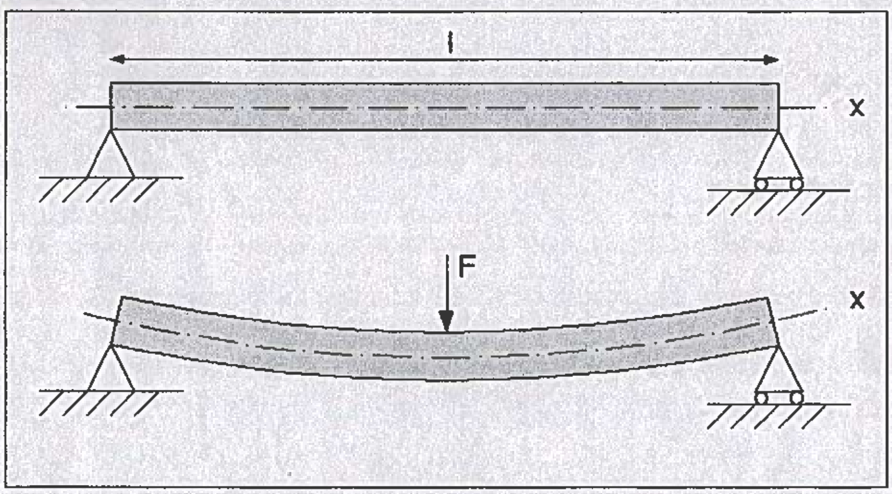
L = Length of the beam between the two knife edges.

b = Breath of the beam.

d = Thickness of the beam.

δ = Depression of the beam in the middle.

Required Diagram:-



E-mail:- sicoambala@gmail.com

Cell:- 097281-28359

Useful Theory:-

The Elasticity is the property of materials by virtue of which it tend to resist a deforming force and recover from a change of size or shape of the body on removal of the deforming force. When the deforming force is applied to a body in such a manner that its length is changed, then a *longitudinal strain* is produced in the body. Due to the elastic property, an internal restoring force is produced along the length of the body which opposes the deforming force. The magnitude of this force per unit cross-sectional area is called the *normal stress*. If the body is of length L and have uniform cross-sectional area A, and if a force F acting along the length
of the body changes the length by l, then

Longitudinal Strain= l/L & Normal Stress= F/A

So Young Modulus = Normal Stress/Longitudinal Strain (Newton/m2)

Procedure for observation:-

1. Firstly fitted the edge in table with the gap 1 mtr, put the beam over it, also inert hook edge in the center of beam.
2. Now make electrical connecting of assembly through spherometer, galvanometer, battery eliminator, Rheostat through DCC Wire.
3. Now put exactly the spherometer tip to hanger surface.
4. ½ kg weight is placed in the hanger which disturbs the balance as the beam depresses in the middle.
5. Now grove the spherometer till it touch on the hanger surface or galvo give deflection.
6. The load is increased gradually in steps & note the change in spherometer reading
7. After few readings, the above procedure is repeated for load decreasing.
8. The mean depression is calculated with the help of above mention formula.
9. Measure the distance between the two knife edges with meter scale.

10. Measure the breadth of the beam at different points with help of vernier caliper & take mean of it.

Observation table for reading:-

Sr.No	Load in the hanger kg.	Spherometer reading Load Inc.(a)cm	Spherometer reading Load Dec.(b)cm.	Mean (a+b)/2	Shift in the image for 2.5kg cm.	Mean.
	50g					

Material of the sample beam = _ _ _
Length, L = _ _ _
Breadth, b = _ _ _
Depth, d = _ _ _
Least count of the spherometer is, $L.C.$ = : : : mm.

Result:
Young's modulus of elasticity of '*material name*' is, Y = : : : Nm^{-2}.

500g 6.59 6.59
1kg 5.57
1.5kg 3.31

S.NO	Load in Hanger (kg)	Spherometer Reading Load Increasing (mm)	Spherometer Reading Load Decr. (mm)	Mean	Shifting image	Mean (mm)

Hook`s Law Experiment.

Objective:-

To study the elastic forces & verify the hooks law , also determine the spring constant.

Apparatus

- An arrangement two hanging different spring with pointer
- All metallic frame with long printing scale.
- Stop Watch.
- Slotted Weights

Useful Diagram For Observation:-

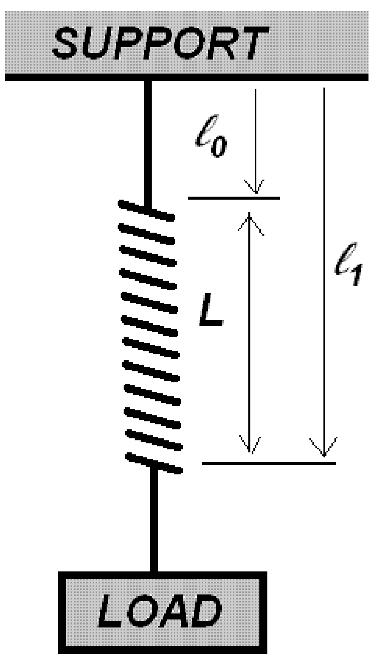


Figure 1. Spring and load

Useful Introduction :-

If it is not stretched to the point where it becomes permanently deformed, the behavior of a properly wound coiled spring, when subjected to a stretching force, can be expected to follow Hooke's Law. [Bueche, p. 95] (Note that Hooke's Law applies more generally to many more systems than just ordinary springs.) To see whether an ordinary screen door spring behaves similarly, one such spring was suspended by one end from a horizontal support and masses were hung from its other end to stretch it as shown in Figure 1. The resulting data were used to construct a graph of load as a function of elongation, from which it was possible to obtain the spring constant of the spring. In addition, for one value of load the spring was given a small additional stretch and released, thereby setting the system into vertical oscillation. Assuming this motion to be simple harmonic, its period also yields a spring constant, thereby providing an additional check.

Useful Theory:-

If a weight, $W = mg$, is hung from one end of an ordinary spring, causing it to stretch a distance x, then an equal and opposite force, F, is created in the spring which acts to oppose the pull of the weight. If W is not so large as to permanently distort the spring, then this force, F, will restore the spring to its original length after the load is removed. F is thus called an elastic force and it is well known that the magnitude of an elastic restoring force is directly proportional to the stretch,

$$F = kx$$

A relationship called Hooke's Law after the 17th century scientist who studied it. The constant k is called the spring constant, or stiffness coefficient. To emphasize that x refers to the change in length of the spring we write

$$F = mg = k\Delta l$$

In this form it is apparent that if a plot of F as a function of Δl has a linear.

An additional approach is possible. One definition of simple harmonic motion (SHM) is that it is motion under a linear, "Hooke's Law" restoring force. For such a motion we have, from Newton's second law,

$$F = - kx = ma.$$

The minus sign appears since in this case the acceleration of the object in SHM is in the direction opposite to the force causing it. From this definition

$$T=2\prod\sqrt{m/k}$$

Experimental Procedures:

- Firstly make complete assembly as shown in figure above 2.
- Note hang the slotted weights.
- Spring start oscillation note the oscillation & their time.
- Also note their tension displacement in scale in cm.
- Firstly note in increasing order & then decreasing order.
- Now for the measure of spring constant note the oscillation & taken time..
- Note displacement, time & oscillation in the observation table as given below..

Observation Procedures:

- Mass of spring S1.............. & S2....................

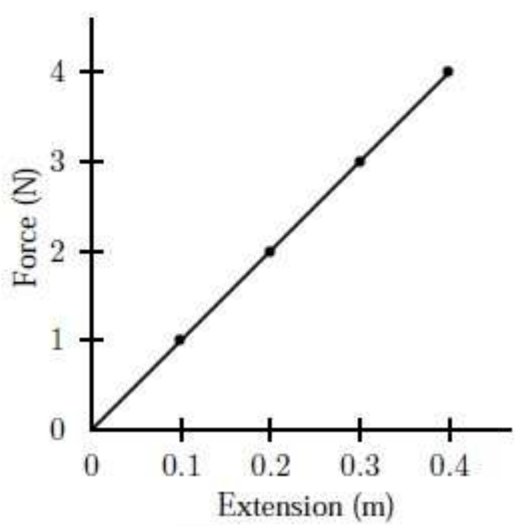
For Spring Constant..

Hanging Mass in gram	Pointer Position in L cm	Extension in ΔL cm	Slope of k using graph
	L0	L1-Lo	
	L1	L2-Lo	
	L2	L3-Lo	

For measure time using SHM

Hanging Mass in gram	Time for Osc 10 in Sec	Time Period T/10 Sec	Time By Formula $T= 2\prod\sqrt{m/k}$

Graph..



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(Newton Ring Experiment)

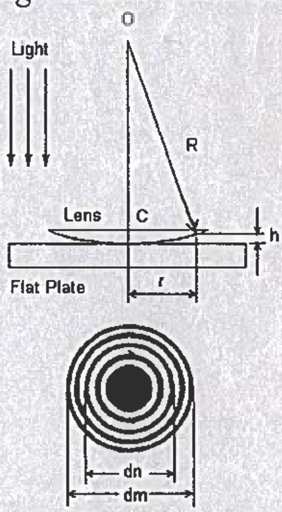
Aim:- To study & determine the wavelength of monochromatic light using Newton`s Rings.

Setup Contains:-

1. Six Position Newton Ring Microscope 2 motion with 10X Eye Piece..
2. Wooden Frame 45 ` Degree with plano and plane Lens.
3. Wooden Box for Sodium light source.
4. Sodium vapour lamp transformer 35 Watt.
5. Philips/GE Make Sodium lamp 35 Watt.
6. Spherometer .
7. Meg. Lens .

Basic Theory:-

(a). 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.



(b). 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. 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. When viewed with the white light, the fringes are coloured. A horizontal beam of light falls on the glass plate B at an angle of 450. The plate B reflects a part of incident light towards the air film enclosed by the lens L and plate G. The reflected beam from 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.As shown fig(1).

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Cell:- 097281-28359

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Formula Used:-

The Wavelength λ of light is given by the formula.

$$\lambda = \frac{(D^2n+p) - (D^2n)}{4pR.}$$

Where,
Dn+p = Diameter of (n+p)th ring.
Dn = Diameter of nth ring.
P = An integer number(of the rings).
R = Radius of curvature of the curved face of the plano-convex lens.

Operating Procedure:-

1. Monochromatic light assembly is use as light source(Firstly take wooden box , put sodium lamp inside it than connect their power cord to the transformer 35 watt & transformer to main supply).
2. Switch ON main AC & Also ON Transformer than light start glow wait until light became steady.
3. Take Newton's Rings frame with plano convex & plane lens put front of light then mounted mirror adjust at 45 degree.
4. Align Six Position Microscope top of Newton Ring Wooden Angle Frame , now focus the telescope until you see the circular fringes. If fringes is not visible than adjust the drum or screw of glass assembly.
5. Set cross wire in center then take reading in order n, n+4, n+8....in left & right side as shown in observation table(1), so that we get value of diameter of different order.
6. For measurement of radius of curvature take lens assembly & spherometer.
7. The radius of curvature of the plano-convex lens is determined by this formula $R = l^2/6h + h/2$, where l is the distance between the two legs of the spherometer, h is the difference of the readings of the spherometer when it is placed on the lens as well as when placed on plane surface.
8. After taking reading of diameter & radius of curvature put their values in formula & get value of wavelength.

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1. **Observation Table for determine of $(D^2n+p - D^2n)$.**
Least count of Micrometer :-................mm. Where L.C= Pitch/ Total Circular division.

No of Fringes	Micrometer Readings Left (a) Right(b)	Diameter D (a-b) cm	$D^2(n+p)$- D^2n	Mean	p
n					
n+4					
n+8					

---					

2. **Observation Table for determine of R(Radius of curvature).**
Least count of Spherometer = ...mm.
L = L1+L2+L3/3=........cm

Sr.No	Spherometer Reading at plane surface.(a)	Spherometer Reading at plano convex surface.(b)	h = (b-a) cm	Mean h cm.
01				
02				
03				

Calculation for result:-

Taking the value of (D^2n+p-D^2n) form observation table 1 & value of R form observation table 2, by using formula Radius of curvature.
Put Value in Formula for λ
So Value of wavelength of monochromatic light λ.........A°

Result:-
(a). So the determine experimental value of wavelength λ...............A°.
(b). Practical Value of λ= 5893 A°

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Cell:- 097281-28359

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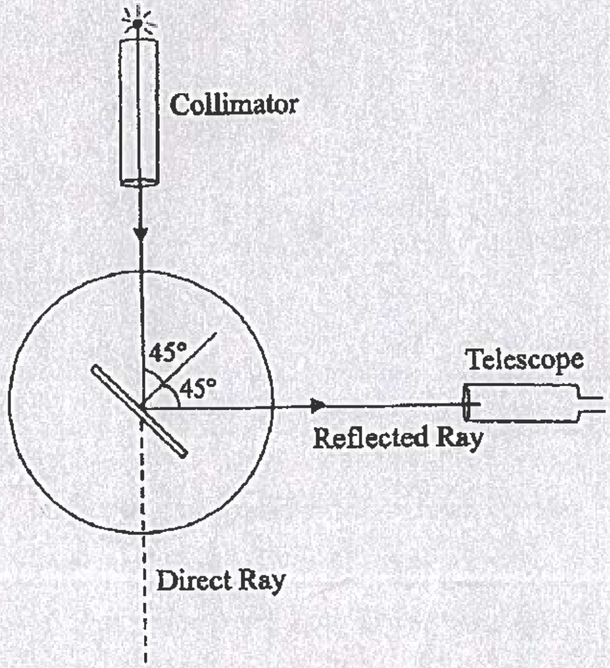
Aim:
To determine the wave length of sodium light by diffraction grating method.

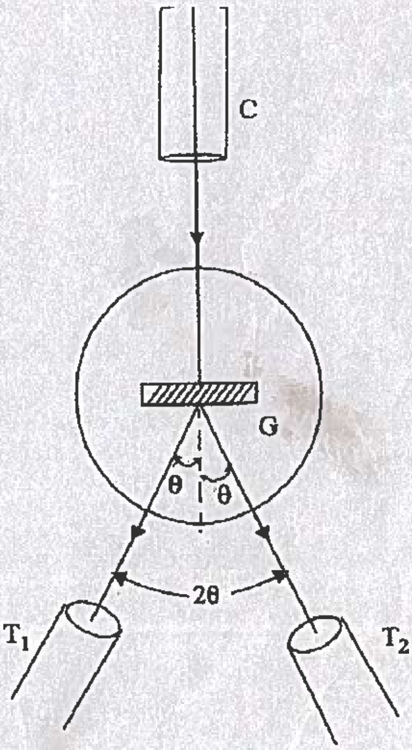
Apparatus required:

- Spectrometer 6 Inch Dia & Least Count - 30 Sec.,
- Diffraction grating 15000 LPI,
- Sodium Vapour Lamp Source 35 Watt with wooden box & lamp 35 Watt
- Spirit Level.
- Reading Lens

Formula:
The wavelength of the spectral line is given by
Number of lines per meter of the grating

Figure:-





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Cell:- 097281-28359

Procedure:

Adjustment of the grating for normal incidence

The preliminary adjustments of the telescope are made. The telescope is brought in front of the collimator and the direct image of the slit is viewed. The image is made to coincide with the vertical cross wire by adjusting the tangential screw of the telescope. The reading of any one of the vernier is taken. The vernier table is clamped and the telescope is rotated through 90° and fixed.

Now, the grating is mounted on the prism table vertically at the centre, with its ruled surface facing the collimator. The prism table is rotated slowly, till the reflected image of the slit coincides with the vertical cross wire, of the telescope. The reading of the Vernier is noted and the Vernier table is rotated through 45° towards the collimator. Now, the surface of the grating is normal to the parallel rays coming from the collimator.

Measurement of number of lines per unit length of the grating

The slit is illuminated by sodium light of known wavelength. After the adjustment of normal incidence, the telescope is released to catch the diffracted image of the first order on the left side of the central direct image. The readings are taken. The telescope is then turned towards the right side to catch the image of the first order. The readings are taken. The difference between the two readings gives 2 θ_N where n is angle of first order diffraction. The number of lines per meter of the grating is calculated using the formula. The experiment is also repeated for the second order

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Observations:-

1. Number of Lines per inches (N) = 15000 .
2. Grating Element (a+b) = 2.54/15000=…….cm.
3. Direct Reading of Both Vernier V_1 =……… & V_2 =…………

Order	Left Side Reading	Right Side Reading	Difference	Angle θ
1st	V1= V2=	V1= V2=		θ_1 =…..
2nd	V1= V2=	V1= V2=		θ_2 =…..

Result:

1. The number of lines per meter of the grating (N) = 15000 LPI
2. The wavelength of prominent lines of the sodium are:

Formula :- $\lambda = \underline{(a+b)\ \text{Sin}\ \theta_n} / n.$

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Cell:- 097281-28359

R 197.5

165.5
181.5

~~Fo~~ Forward

Voltage	Current
0.13	0.05
0.217	0.21
0.412	0.83
0.672	1.86
0.813	2.46
1.046	3.50
1.575	5.98
1.956	7.82

Reverse

V	C
0.53	2.2
1.54	3.2
2.98	4.8
4.05	6.2
6.7	10.1
8.73	13.4
9.85	15.2
13.01	21.5
16.1	27.4
18.13	32.8

n	LHS	RHS	Diff	C
?	~~187~~	~~359~~		

$339 + \frac{8 \times 30}{3600}$

RHS ~~L.~~ L.H.S

$339 + \frac{8 \times 30}{3600}$ 159

339 159

~~144.5~~ 324.5

324.5 144.5

321.5 141.5

~~39~~ 80 64

33

ES - 249

OMEGA

OPERATING INSTRUCTIONS

FOR

NEWTON'S RINGS

EXPERIMENTAL SETUP

OMEGA TYPE ES-249

Manufacturer :

OMEGA ELECTRONICS

INDIA SALES
B-28, FATEH SINGH SCHEME
OPP. RAJPUTANA PALACE SHERATON,
JAIPUR - 302006 (INDIA)
PHONE : 2375647, 2379223
FAX : 091-0141-2204481

MFG/EXPORT/TRAINING
28 E & F, MALVIYA INDUSTRIAL AREA,
JAIPUR - 302017 (INDIA)
PHONE : 2751136, TELEFAX : 2751559
FAX : 091-0141-2204481

EMAIL : omega@sancharnet.in

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OMEGA TYPE ES-249 Experimental Set Up has been designed specifically for the study of the Newton's Rings. The setup consists of Newton's Rings Apparatus, Wooden reflector, Traveling Microscope, Sodium light source, lens etc.

The set up is absolutely self contained and require no other apparatus. Practical experience on this set up carries great educative value for Science and Engineering Students.

OBJECT

- Find out the wave length of sodium light and find the refractive index of liquid by using Newton's rings method.

FEATURES

- The complete Experimental Set-up consists of the following :

1.	**NEWTON'S RINGS APPARATUS**	:	Comprising a pair of glasses one plane and the other slightly convex in metal frame with three screws for applying pressure 60mm dia.
2.	**WOODEN REFLECTOR**	:	It consist of two glass plates one at 45° Angle & another at bottom.
3.	**TRAVELLING MICROSCOPE FOR NEWTON'S RINGS APPARATUS**	:	Bridge type body
4.	**SODIUM LIGHT SOURCE**	:	Sodium light source complete with sodium lamp 35 watts, with vacuum jacket, Transformer & Wooden Box having four holes with slide covers, one each on every side at different heights.
5.	**LENS**	:	Double convex lens with stand.
6.	**SPHEROMETER**		

THEORY

The formation of Newton's rings is due to the interference of light waves reflected from the upper and lower surface of the air film enclosed between the lens and plane glass plate. The thickness of the air film at the point of contact is zero and increases as we move from the point of contact towards the periphery of the lens. The thickness of the air film will be uniform for all points lying on a circle with centre at the point of contact. Thus using reflected light, the central point will be dark surrounded by bright circles separated by dark rings.

If R is the radius of curvature of the lens and t the thickness of the air film at A or B. The necessary condition for bright fringes using reflected light is

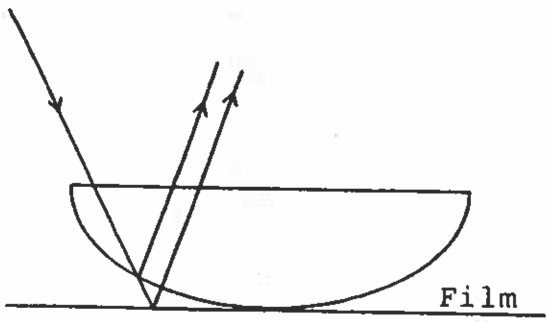


Fig. 1

$$2\mu t\cos\theta = \frac{(2n+1)\lambda}{2} \qquad (1)$$

Where n = 0,1,2.............. Since θ is very small cos θ = 1 (θ is the angle of refraction)

$$2\mu t = \frac{(2n+1)\lambda}{2} \quad \text{(For air } \mu = 1) \qquad (2)$$

and for dark fringes

$$2\mu t = (2n)\lambda/2 = n\lambda,\ n = 0,1,2, \qquad (3)$$

From the geometry of Fig. 2

$$EB \times AE = EO \times ED$$

EB = AE = r the radius of interference fringe

EO = BQ = t (thickness of the film)

$$r^2 = t(2R - t) = 2Rt$$

2

neglecting t^2 in comparition to 2Rt

$$\therefore \quad t = \frac{r^2}{2R} \tag{4}$$

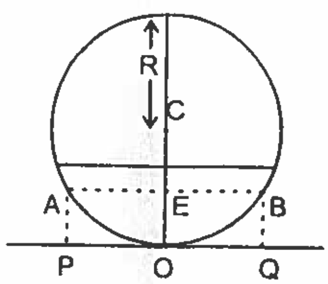


Fig. 2

$\therefore$ For bright fringe

$$2\mu \frac{r^2}{2R} = \frac{(2n+1)\lambda}{2}$$

or

$$r = \sqrt{\frac{(2n+1)R\lambda}{2\mu}} \tag{5}$$

and for dark fringe

$$r = \sqrt{\frac{n\lambda R}{\mu}} \tag{6}$$

When n = 0, the radius of dark fringe is zero and the bright fringe is $\sqrt{\lambda R}$ .Therefore alternately dark and bright fringes are produced with dark centre. Suppose the diameter of the n^{th} dark fringe be D_n then

$$D_n^2 = \frac{4n\lambda R}{\mu}$$

and the diameter of $(n + p)^{th}$ ring be D_{n+p}, then

$$\therefore \quad D_{n+p}^2 = \frac{4(n+p)\lambda R}{\mu}$$

$$\therefore \quad D_{n+p}^2 - D_n^2 = \frac{4p\lambda R}{\mu} \tag{7}$$

(μ = 1 for air film)

$$\therefore \quad D_{n+p}^2 - D_n^2 = 4p\lambda R \tag{8}$$

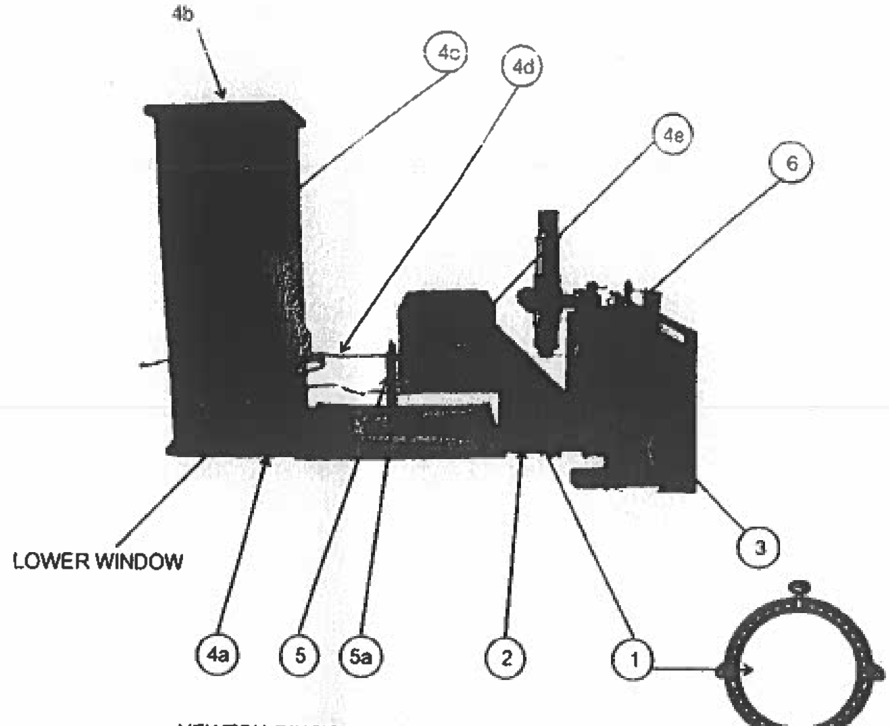
$$\boxed{\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}} \tag{9}$$

For bright fringes also

$$\therefore \quad D_{n+p}^2 - D_n^2 = 4p\lambda R \tag{10}$$

DESCRIPTION OF APPARATUS

The optical arrangement for Newton's ring is shown in fig. 3. Light from a monochromatic source (sodium light) is allowed to fall on a convex lens through a broad slit which renders it into a nearly parallel beam. Now it falls on a glass plate inclined at an angle 45⁰ to the vertical, thus the parallel beam is reflected from the lower surface. Due to the air film formed by a glass plate and a Plano - convex lens of large radius of curvature, interference fringes are formed which are observed directly through a traveling microscope. The rings are concentric circles



NEWTON' RING'S EXPERIMENTAL SET-UP FOR ES-249

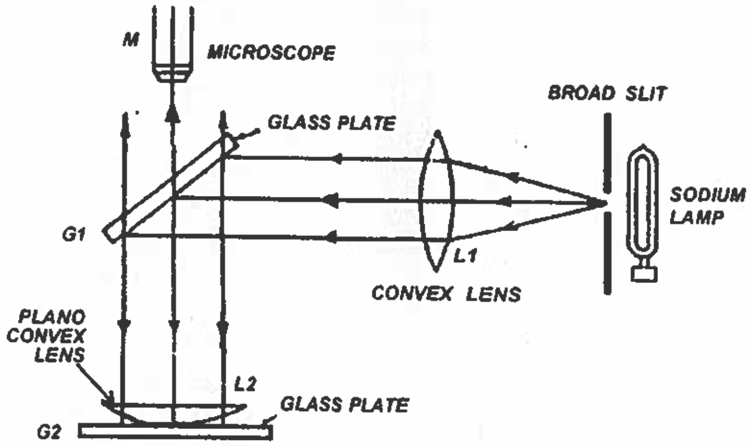
1. NEWTONS RINGS DIA 60mm APP. ALUMINUM FRAME
2. WOODEN REFLECTOR +PLANE GLASS +BLACK PAINT GLASS
3. TRAVELING MICROSCOPE FOR NEWTONS RING APP. BRIDGE TYPE BODY
4. SODIUM LIGHT SOURCE

4a. WOODEN CABINET FOR SODIUM LIGHT
4b. LAMP HOLDER FOR SODIUM LAMP 35W
4c LAMP 35W TUBLER SHAPE LPSV
4d. MAINS LEAD 2PIN
4e. TRANSFORMER FOR 35W SODIUM LAMP

5. DOUBLE CONVEX LENS DIA50MM,FL10CM

5a. LENS HOLDER 'V' SHAPE WOODEN

6. SPHEROMETER WITH S. SCREW



PROCEDURE

(i) Before starting the experiment, the glass plates G_1 and G_2 and the Plano convex lens should be thoroughly cleaned.

(ii) The centre of lens L_2 is well illuminated by adjusting the inclination of glass plate G_1 at 45°.

(iii) Focus the eyepiece on the cross-wire and move the microscope in the vertical plane by means of rack and pinion arrangement till the rings are quite distinct. Clamp the microscope in the vertical side.

(iv) According to the theory, the centre of the interference fringes should be dark but sometimes the centre appears white. This is due to the presence of dust particles between glass plate G_2 and plano-convex lens L_2. In this case the lens should be again cleaned.

(v) Move the microscope in a horizontal direction to one side of the rings. Fix up the crosswire tangential to the ring and note this reading. Again the microscope is moved in the horizontal plane and the cross wire is fixed tangentially to the successive bright rings noting the vernier readings till the other side is reached. This is shown in fig. 4.

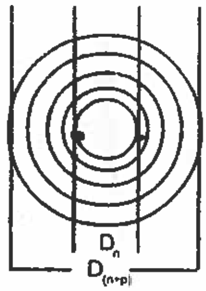


Fig. 4

(vi) The radius of the curvature of the Plano convex lens can be determined by using a spherometer. In this case

$$R = \frac{l^2}{6h} + \frac{h}{2}$$

Where l is the distance between the two legs of the spherometer as shown in fig. 5

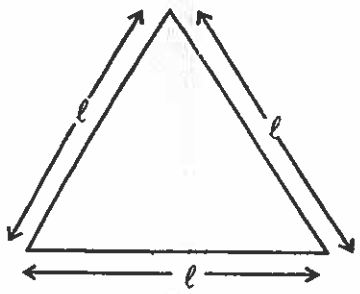


Fig. 5

h is the difference of the readings of the spherometer when it is placed on the lens as well as when placed on plane surface.

Observations : Value of one division of the main scale = ...cm.
No. of divisions on the vernier scale = ...
Least count of the microscope = ...

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Table for determination of ($D^2_{n+p} - D_n^2$)

No. of the rings	Micrometer reading Left end a cm.	Micrometer reading Right end b cm.	Diameter D (a - b) cm	D^2 $(a-b)^2$ cm^2	($D^2_{n+p} - D_n^2$) cm^2	Mean cm^2	p
20	...	...	...	...			
19	...	...	...	...			
18	...	...	...	...			
17	...	...	...	...			
16	...	...	...	...	...		
15	...	...	...	...	...		
14	...	...	...	...	...		
13	...	...	...	...	...	...	...
12	...	...	...	...	...		
11	...	...	...	...	...		
10	...	...	....	....	...		
9	...	...	...	...	...		
8	...	...	...	...	...		
7	...	...	...	...			
6	...	...	...	...			
5	...	...	...	...			

L.C. of spherometer = ...cm.

S. No.	Spherometer Reading: Zero reading on Plane surface. M.S.	V.S.	Total cm (a)	Reading on lens M.S.	V.S.	Total cm. (b)	h = (a - b) cm.	Mean h cm.
1.	...	...	...	...	...	...	...	
2.	...	...	...	...	...	...	...	...
3.	...	...	...	...	...	...	...	

Distance between the two legs of spherometer l = ...cms.

Using Spherometer method $R = \frac{l^2}{6h} + \frac{h}{2}$

$= $ ...cm.

The wavelength of sodium light is given by

$$\lambda = \frac{D^2_{n+p} - D^2_n}{4pR}$$

$$= \ldots A.U.$$

The value of $(D^2_{n+p} - D_n^2)$ can also be obtained using a graph as shown in figure 6. The graph is plotted between the square of diameter of the ring along Y-axis.

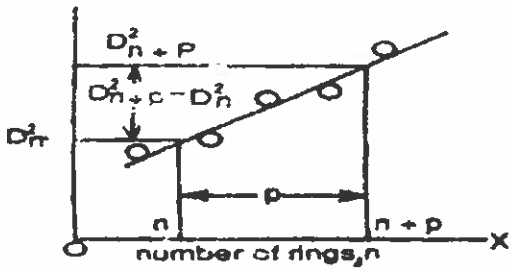

Fig. 6

Result

The mean wavelength λ of sodium light = ...A.U.
Standard mean wavelength λ = ...A.U.
Percentage error = ...%.

ADDITIONAL EXPERIMENT

DETERMINATION OF REFRACTIVE INDEX OF LIQUID BY NEWTON'S RING METHOD

Formula Used

From the (equation 7) $$\mu = \frac{4p\lambda R}{D^2_{n+p} - D^2_n}$$

Where D_{n+p} = diameter of (n + p)th ring,
D_n = diameter of nth ring,
p = an integer number (of the rings),
R = radius of curvature of the curved face of the Plano-convex lens and
λ = wavelength of monochromatic source used (sodium light).

PROCEDURE

To determine the refractive index of given liquid introduce 2-3 drops of it between glass plate and Plano convex lens and proceed as above.

Sources of Error and Precautions

(i) Glass plates and lens should be cleaned thoroughly.
(ii) The lens used of large radius of curvature.
(iii) The source of light used should be an extended one.
(iv) Before measuring the diameters of rings, the range of the microscope should be properly adjusted.
(v) Crosswire should be focused on a bright ring tangentially
(vi) Radius of curvature should be measured accurately.

REFRENCES

1. Practical Physics : By Gupta & Kumar Vol.1.
2. Practical Physics B.Sc. Part 2 : By Kakani.

ENCLOSURES : NIL.

ACCESSORIES: NIL.

GPA160309

Expt. 1: Study of Newton's ring and determination o wavelength of Sodium light

Background

Coherent light
Phase relationship
Path difference
Interference in thin film
Newton's ring apparatus

Aim of the experiment

To study the formation of Newton's rings in the air-film in between a plano-convex lens and a glass plate using nearly monochromatic light from a sodium-source and hence to determine the radius of curvature of the plano-convex lens.

Apparatus required

A nearly monochromatic source of light (source of sodium light)
A plano-convex lens
An optically flat glass plates
A convex lens
A traveling microscope

Theory

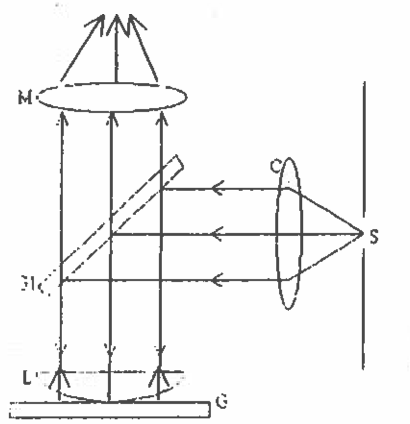

Fig. 1 Experimental set-up to observe Newton's ring

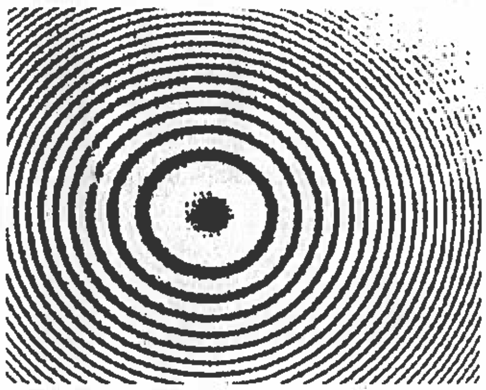
Fig. 2. Newton's rings

When a parallel beam of monochromatic light is incident normally on a combination of a plano-convex lens L and a glass plate G, as shown in Fig.1, a part of each incident ray is reflected from the lower surface of the lens, and a part, after refraction through the air film between the lens and the plate, is reflected back from the plate surface. These two reflected rays are coherent.

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hence they will interfere and produce a system of alternate dark and bright rings with the point of contact between the lens and the plate as the center. These rings are known as Newton's ring.

For a normal incidence of monochromatic light, the path difference between the reflected rays (see Fig.1) is very nearly equal to $2\mu t$ where μ and t are the refractive index and thickness of the air-film respectively. The fact that the wave is reflected from air to glass surface introduces a phase shift of π. Therefore, for bright fringe

$2\mu t = \left(n + \frac{1}{2}\right)\lambda$; n = 0,1,2,3 (1)

and for dark fringe

$2\mu t = n\lambda$; n = 0,1,2,3 (2)

For n-th (bright or dark) ring (see Fig. 2), we also have

$$\frac{D^2_n}{4} + (R-t)^2 = R^2 \qquad (3)$$

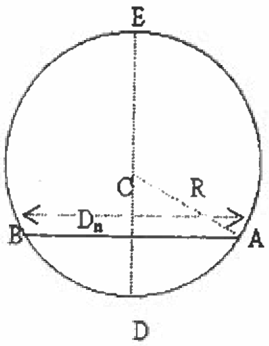

Fig. 2 Geometry used to determine the thickness of the air-film

where D_n = the diameter of the n-th ring and R = the radius of curvature of the lower surface of the plano-convex lens. On neglecting t^2, equation (3) reduces to

$$D_n^2 = 8tR \qquad (4)$$

From equations (1) and (4), we get,

$$D_n^2 = 4\left(n + \frac{1}{2}\right)\frac{\lambda R}{\mu}, \text{ for } n\text{-th bright ring} \qquad (5)$$

$$D^2_{n+m} = 4\left(n + m + \frac{1}{2}\right)\frac{\lambda R}{\mu},$$

for $(n+m)$-th bright ring (6)

Similarly, from equations (2) and (4), we obtain

$$D_n^2 = \frac{4n\lambda R}{\mu}, \text{ for } n\text{-th dark ring} \qquad (7)$$

$$D_{n+m} = \frac{4(n+m)\lambda R}{\mu}, \text{ for } (n+m)\text{-th dark ring} \qquad (8)$$

Thus for bright as well as dark rings, we obtain

$$R = \frac{\mu\left(D^2_{n+m} - D_n^2\right)}{4m\lambda} \quad \ldots \quad (9)$$

Since $\mu = 1$ for air-film, above equation gives

$$R = \frac{\left(D^2_{n+m} - D_n^2\right)}{4m\lambda} \quad \ldots \quad (10)$$

(9)

Procedure

1. Level the traveling microscope with its axis vertical. Arrange the set-up as shown in Fig.1 and focus the microscope on the air-film. Newton's Rings will be clearly seen.

2. Adjust the glass plate G1 for maximum visibility of the point of contact of lens L with the glass plate G and hence for maximum visibility of Newton's Rings. In this orientation, G1 is at 45^0 to the incident beam of light.

3. Move the microscope to the right of the central dark spot (say order 'n', this is because the central ring is often broad and may not necessarily will be zero order) and set it on the extreme tenth ($n+10^{th}$ order) distinct bright ring so that the cross-wire perpendicular to the direction of movement of the microscope passes through the bright ring and is tangential to it. Record the microscope position from the horizontal scale along with its number with bright ring around the central dark spot as the first bright ring. Move the microscope to left and record the position of the next bright ring. Repeat it till you reach to the tenth bright ring on the left. From these measurements, evaluate the diameters of different rings. Repeat these measurements for microscope movement from left to right and evaluate the diameters of different rings. Determine the average diameters of different rings.

Observations

Vernier constant for the horizontal scale of the microscope (Least Count) :

Table 1

Measurements of the diameter of the ring

Ring No. (n)	Microscope readings (cm) on the						Diameter D_{n+m}= R_1-R_2 (cm)	D^2_{n+m} (cm^2)	m_1-m_2	$D^2_{n+m_1}-D^2_{n+m_2}$ (cm^2)
	Left (R_1)			Right (R_2)						
	Main Scale	Vernier	Total	Main scale	Vernier	Total				
n+10										
n+9										
n+8										
n+7										
n+6										
n+5										
n+4										
n+3										
n+2										
n+1										

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Calculation and Results

Plot a graph between $D^2_{n+m_1} - D^2_{n+m_2}$ vs m_1-m_2

Table 2

Calculation of radius of curvature, R, from the graph

$D^2{}_{n+m_1} - D^2{}_{n+m_2}$ (cm^2) from graph	m_1-m_2	λ (cm) (5893×10^{-8})	$R = \dfrac{D^2{}_{n+m_1} - D^2{}_{n+m_2}}{4(m_1 - m_2)\lambda}$ (cm)

Estimate error in R

The radius of curvature is calculated from Equation (3), viz.

$$R = \frac{D^2_{n+m_1} - D^2_{n+m_2}}{4(m_1 - m_2)\lambda}$$

Since D_{n+m_2} and D_{n+m_1} are only measured, the maximum proportional error in R is given by

$$\frac{\delta R}{R} = \frac{\delta\left(D^2_{n+m_1} - D^2_{n+m_2}\right)}{D^2_{n+m_1} - D^2_{n+m_2}} = \frac{2(\delta D_{n+m_1})D_{n+m_1} + 2(\delta D_{n+m_2})D_{n+m_2}}{D^2_{n+m_1} - D^2_{n+m_2}}$$

Since D_{n+m_1} or D_{n+m_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. $2v.c.$

Therefore, $\delta D_n = 2v.c$

Hence, $\frac{\delta R}{R} = 4v.c \frac{(D_{n+m_1} + D_{n+m_2})}{D^2_{n+m_1} - D^2_{n+m_2}} = \frac{4v.c}{(D_{n+m_1} - D_{n+m_2})}$

Discussion

(i) The Newton's ring experiment can be also used to find the wavelength of a monochromatic light. In this case, the radius of curvature of the convex surface of the given lens is supplied or is determined otherwise. By employing sodium light whose mean wavelength is 5893Å, R can be determined from Eqn.(3), as in the present experiment. Then the same equation can be used to find the wavelength λ of any other given monochromatic light.

(ii) R is calculated from Eq. (10). An error in the actual ring number $n+m_1$ does not affect the result.

(iii) Since the first few rings near the center are deformed, they must be avoided while taking readings for the rings.

(iv) Care must be taken not to disturb the lens and glass plate combination in any way during the experiment.

Questions

1. In the Newton's ring experiment, how does interference occur?
2. Where have the fringes formed?
3. Why are the fringes circular?
4. Are all rings equispaced?
5. Why is an extended source used in this experiment?
6. What will happen if a point source or an illuminated slit is used instead of the extended source?
7. In place of lens, if a wedge shaped film formed by two glass plates is supplied to you, will you be able to observe Newton's ring? Why?
8. How is the central spot in your experiment, bright or dark? Why?
9. Instead of reflected rays, if you look at transmitted rays, what do you expect to observe?
10. What happens with the central spot when a liquid of refractive index μ greater than that of the lens and less that that of the glass plate is introduced between the lens and the glass plate?
11. Is it possible to determine the refractive index of the liquid by this experiment?
12. What would happen to the ring if the space between lens and the plate is filled with a liquid of refractive index μ?
13. What do you expect to see in the microscope if you use a white light source?
14. What is the difference between biprism fringes and Newton's ring fringes?
15. On which factors does the diameter of a ring depend?
16. What would happen if a glass plate is replaced by a plane mirror?
17. Why should a lens of large radius of curvature be used in this experiment?
18. Is it desirable to measure the radius of curvature of the given lens by a spherometer in the usual way?
19. What do you understand by (a) fringes of equal thickness (b) fringes of equal inclination and (c) fringes of equal chromatic order.
20. How does the sodium source, which you are using in your experiment work?

References

1. Fundamental of Optics by F. Jenkins and H. White 535 JEN/F
2. Optics by A.Ghatak 535 GHA/O
3. Optics by E. Hecht 535 HEC/O

Graph : Newton's Rings

Experiment No. 4

Wavelength of Sodium light with the help of Fresnel's biprism

(9) A

M I of R M

3 Bh

TORSIONAL PENDULUM – RIGIDITY MODULUS

Expt.No:
Date :
Aim:

To determine the rigidity modulus of the material of the wire and the moment of inertia of a circular disc about its axis of suspension by the method of torsional oscillations.

Objective:

To understand the concept of moment of inertia and rigidity modulus using torsional pendulum.

Apparatus required:

Circular disc with chuck, given wire (suspension wire), stop clock, two equal cylindrical masses, screw gauge and metre scale.

Formula:

Moment of inertia of the disc $I = \frac{MR^2}{2}$ kg m²

Rigidity modulus of the material of the wire $n = \frac{8\pi I}{r^4}\frac{L}{T^2}$ N/m²

Where

M = mass of the disc (kg)
T = Period of oscillation of the Torsion pendulum (second)
R = Radius of the Torsion disc (metre)
L = length of the suspension wire (metre)
r = Radius of the Pendulum wire (metre)

Theory:

Torsion pendulum consists of a metal wire clamped to a rigid support at one end and carries a heavy circular disc at the other end. When the suspension wire of the disc is slightly twisted, the disc at the bottom of the wire executes torsional oscillations such that the angular acceleration of the disc is directly proportional to its angular displacement and the oscillations are simple harmonic.

Dw => 340gm

2/3

Table II: Determination of the diameter of the suspension wire using screw gauge

Least count L.C = 0.01 x 10^{-3} m
Zero Error (Z.E) = _______ Divisions
Zero Correction (Z.C) = (Z.E x L.C) = ______ x 10^{-3} m

S.No	P.S.R x10^{-3}m	H.S.C Divisions	H.S.R =H.S.C x L.C X10^{-3}m	T.R =(P.S.R + H.S.R+ Z.C) x10^{-3}m

Mean diameter of the wire (2r) = x10^{-3}m

Calculations:

Circumference of the Disc	$2\pi R$ =	x10^{-2}m
Radius of the Disc	R =	x10^{-2}m
Mass of the disc	M =	x10^{-3} kg
Radius of the wire	r =	x 10^{-3} m

Moment of inertia of the disc $I = \frac{MR^2}{2}$ kg m^2

Rigidity modulus of the material of the wire is $n = \frac{8\pi I}{r^4}\frac{L}{T^2}$ N/m^2

Procedure:

One end of a long, uniform wire whose rigidity modulus is to be determined is clamped by a vertical chuck. To the lower end, a heavy uniform circular disc is attached by another chuck. The length of the suspension 'l' (from top portion of chuck to the clamp) is fixed to a particular value (say 60 cm or 70 cm). The suspended disc is slightly twisted so that it executes torsional oscillations. The first few oscillations are omitted. By using the pointer, (a mark made in the disc) the time taken for 10 complete oscillations are noted. Three trials are taken. Then the mean time period T (time for one oscillation) is found. The above procedure is repeated for three different length of pendulum wire. From the above values of L and T calculate L/T^2.

The diameter of the wire is accurately measured at various places along its length with screw gauge. From this, the radius of the wire is calculated. The circumference of the disc is measured and from that the radius of the disc is calculated. The moment of inertia of the disc and the rigidity modulus of the wire are calculated using the given formulae.

3/3 Bh

Table I. Determination of Time period of Oscillation

Mass of the disc (M) = x 10^{-3} Kg

Length of the pendulum (L) x10^{-2}m	Time for 10 oscillations (second)				Time Period (T) second	$\frac{L}{T^2}$ x10^{-2}m s^{-2}
	Trial I	Trial II	Trial III	Mean		

Mean $\frac{L}{T^2}$ = x10^{-2}m s^{-2}