Experiment No. - 1

* Aim :-

To determine the numerical aperture of the optical fibre cable.

* Material Required :-

optical fibre, mandrel, measuring scale, a plane having desired diameter of circle.

* Theory :-

i) Numerical aperture of any optical system is a measure of how much light can be collected by the optical system.

ii) It is the product of the refractive index of the incident medium and the sine of maximum ray angle.

iii) For a step - index fiber as in the present case, the numerical aperture is given by

$$N = \sqrt{n_{core}^2 - n_{cladding}^2}$$

iv) For very small difference in refractive index the equator reduces to.

$$NA = n_{core}\sqrt{2\Delta}$$

where, Δ is the fractional difference in refractive indices NA is numerical aperture.

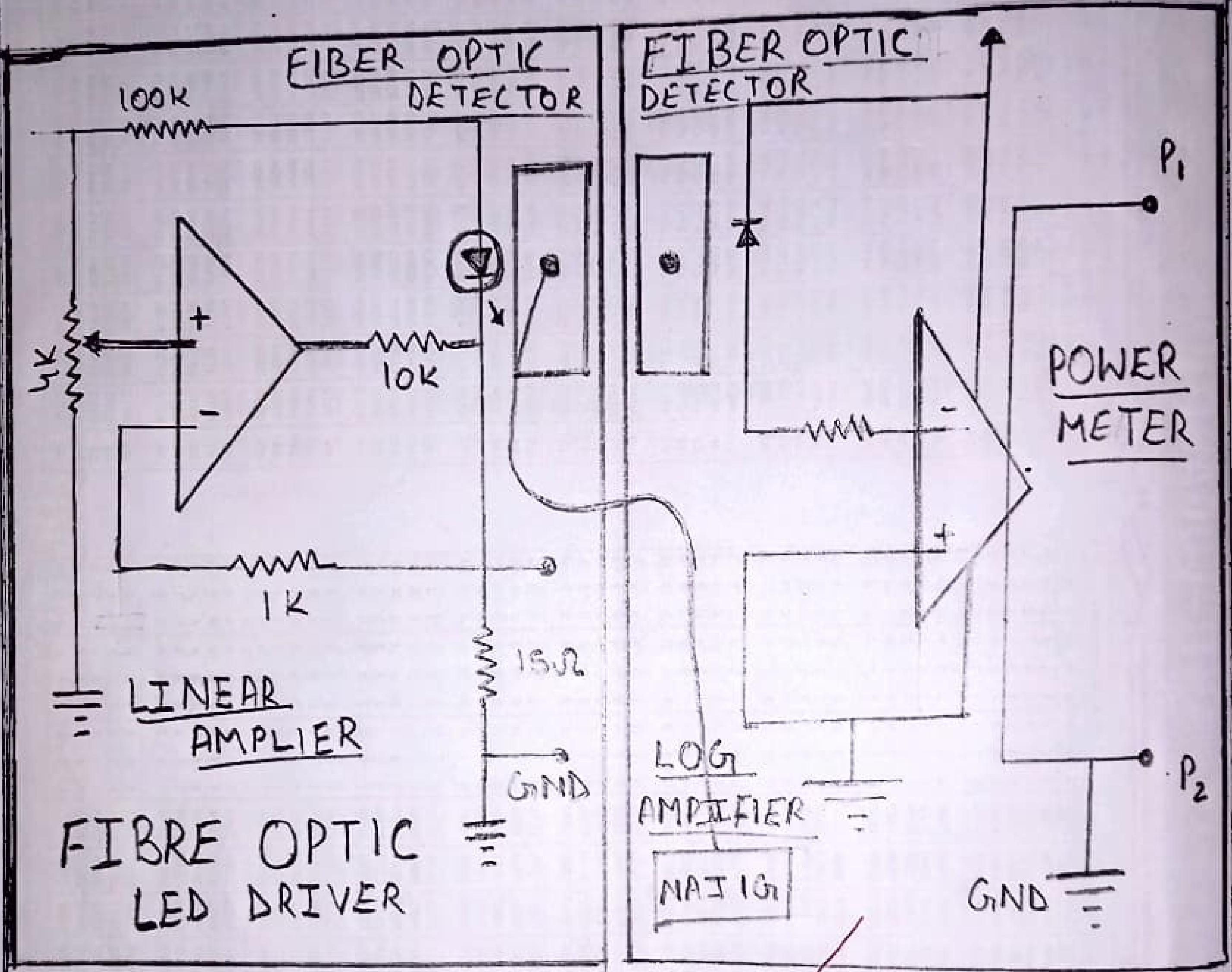
* Formula Used :-

$$NA = \sin\theta_{max} = \frac{W}{\sqrt{4L^2 + W^2}}$$

where, NA is numerical operture
θ_{max} is the acceptance angle

Teacher's Signature

WIRING DIAGRAM



* **Observation**

S.No	L (mm)	W (mm)	NA	θ (degree)	2θ (degree)
1.	9	10	0.485	29.01	58.02
2.	14	16	0.496	29.73	59.46
3.	19	20	0.466	27.77	55.54
4.	24	24	0.472	28.16	56.32

$2\theta_{avg} = 57.34$

$NA_{avg} = 0.4797 \simeq 0.480$

W is the diameter of the circle
L is the distance between fiber optic cable and diameter of circle.

* Calculations :-

$$2\theta \text{ avg.} = \frac{58.02 + 59.46 + 55.54 + 56.32}{4}$$

$$2\theta \text{ avg.} = 57.34$$

$$NA \text{ avg.} = \frac{0.485 + 0.496 + 0.466 + 0.472}{4}$$

$$NA \text{ avg.} = 0.480$$

* Percentage error :-

NA actual (according to lab Manual) = 0.50

$$\% \text{ error} = \frac{0.50 - 0.48}{0.50} = 4.02\% \text{ (approx)}$$

* Result :-

The numerical aperture is 0.480 and acceptance angle is 57.34°.

* Precautions :-

i) The optical fibre must be taut and shoudn't have tunes.
ii) The connection with the trainer must be Tight.
iii) The length must be measured carefully.
iv) The circle of light must be clear in the diameter.

Experiment No. - 2

*** Aim:-**

To determine the various types of Losses that occur in optical fibre cables.

*** Material Required :-**

optical fibre, mandrel, micrometer, optical device (power meter).

*** Theory:-**

i) Attenuation is an optical fibre result of a number of effects. Attenuations in a fibre due to macro bending and estimate the losses.

ii) The loss as a function of the length of the fiber is measureable only when we use a meter cable too in the experiments.

iii) The optical power at a distance L, in an optical fiber is given by:-

$$P_L = P_0 10^{(-\alpha L/10)} dB$$

α is the typical attenuation coefficient value P_0 is the Launched power.

iv) Loss in fibers expressed in decibels is given by $-10 \log (P_0/P_F)$ where, P_0 is the ~~dea~~ launched power and P_F is power at the forend of the fiber.

v) Losses in fibers occur at fiber joints or slices due to axial displacement, angular displacement, sepration mismatch, of cores diameter, mismatch of numerical apertures, improper

S.NO	P_o (dBm)	Average losses (dBm)	Mean Value (dBm)
1.	15.0	0.7	
2.	20.0	0.6	0.625
3.	25.0	0.6	
4.	30.0	0.6	

figure

*Observation

Initial 15dBm

Turns	Value	diff
n=0	15.0	0.4
n=1	15.4	0.9
n=2	16.8	0.5
n=3	16.8	0.5
n=4	17.8	1.0
n=5	18.3	0.8
n=6	19.1	

Mean = 0.7dBm

Turn	Value	diff
n=0	20	0.8
n=1	20.8	0.7
n=2	21.5	0.6
n=3	22.1	0.5
n=4	22.7	0.4
n=5	23.2	
n=6	23.6	

Mean = 0.6dBm

Initial · 30.6 dBm

Initial ·25 dBm

Turns	value	diff.
n=0	25	0.6
n=1	25.6	0.5
n=2	26.1	0.7
n=3	26.8	0.4
n=4	27.2	0.4
n=5	27.6	0.7
n=6	28.3	

Mean ≃ 0.6dBm

Turns	Value	diff.
n=0	30.6	0.5
n=1	31.1	0.8
n=2	31.9	0.5
n=3	32.4	0.5
n=4	~~[illegible]~~	0.5
n=5	32.9	0.5
n=6	32.4 33.9	

Mean ≃ 0.6 dBm

cleaning and polishing at the ends.

* Formula Used :-

The optical power at a diameter L, in an optical fiber is given by:

$$P_L = P_0 \left(10^{-\alpha L/10}\right) dB$$

where, P_0 is the launched power & is attenuation coefficient.

* Calculations :-

Average losses (dBm)

$$= \frac{(0.7 + 0.6 + 0.6 + 0.6)}{4} \text{ dBm}$$

$$= 0.625 \text{ dBm}$$

The losses should be in between the range of 0.3 and 0.8.

* Result :-

The losses obtained in the optical fiber is 0.625 dBm.

* Precautions :-

i) The reading on micrometer should be recorded with no disturbances and fluctuations.
ii) Micrometer should be fixed properly with the device to avoid any false reading
iii) optical fiber should be fixed properly between the terminals of device.
iv) The turns made on the object should be of ~~[illegible]~~ same diameter in each conditions.

Teacher's Signature

Experiment - 3

*** Aim:-**

To measure the magnetic flux density along the x-axis of elements coil when the distance b/w them is a = R [Radius of coil] and when it is greater and less than this.

*** Material Required:-**

Power supply, digital gauss meter connecting wire, moving magnet, elements coils,

*** Theory:-**

i) field at any point on the axis of current carrying coil. Let E and F are two optical Point element of coil through which current flowing.

Field at P at a distance x from the centre and a distance r from element E is

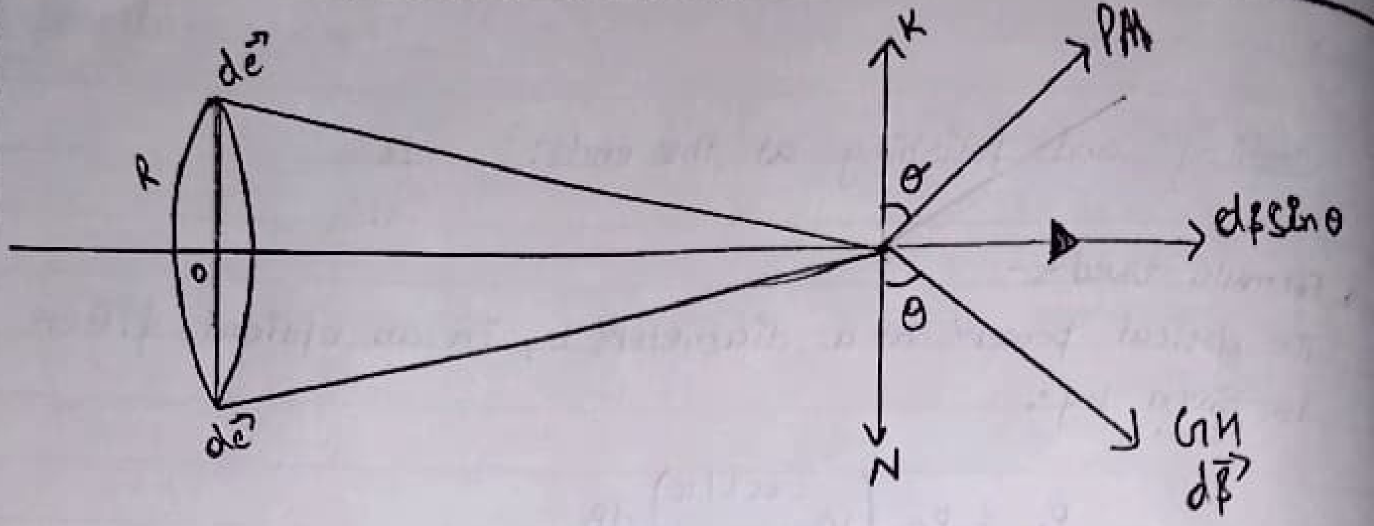
$$\vec{dB} = \frac{\mu_0}{4\pi} \left\{ I \left(\frac{\vec{de} \times \vec{r}}{r^2} \right) \right\}$$

or

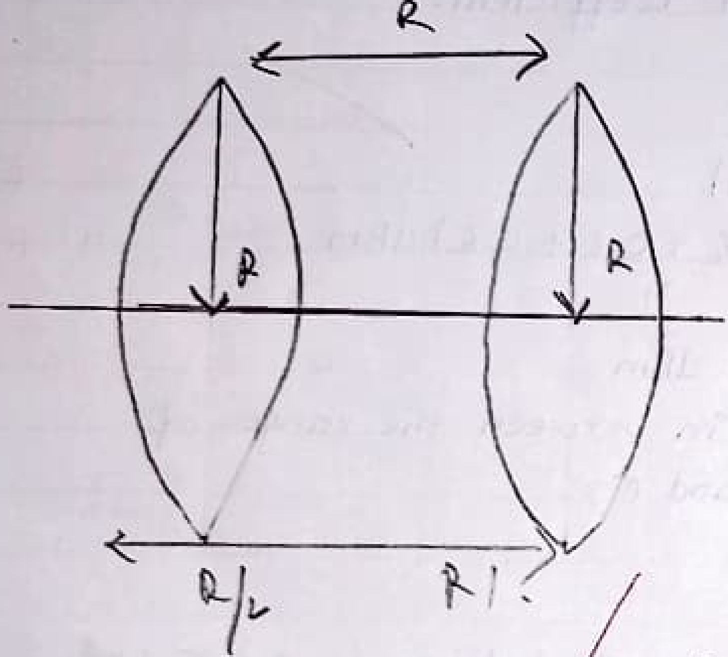
$$\vec{dB} = \frac{\mu_0}{4\pi} \left(\frac{I dl \sin 90 \times r}{r^2} \right)$$

$$\vec{dB} = \frac{\mu_0}{4\pi} \left(\frac{I dl}{r^2} \right)$$

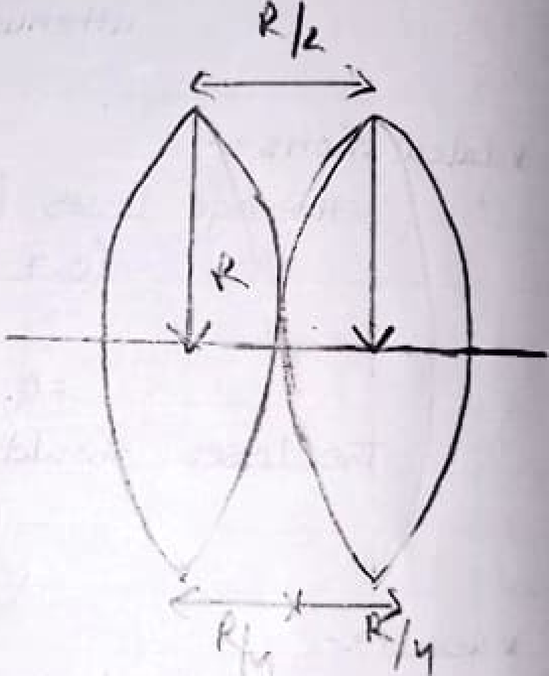
ii) The some field due to element F diameterwlry appait to e acting along LFP. The components dB cos θ get



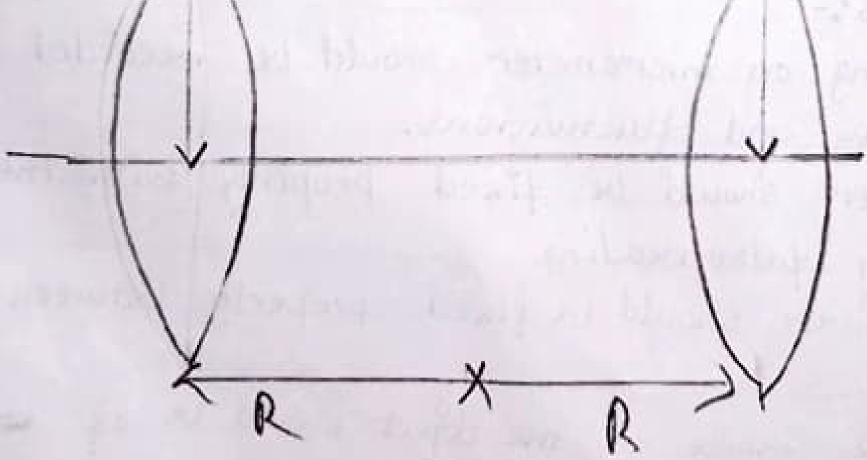
R
O
K
PA
θ
θ
N



R
R
R
R/2



R/2
R
R/4
R/4



2R
R
R

* Observation Table :-

Distance	X (cm)	B (a=R/2)	B (a=R)	B (a=2R)
0	-16.0	0.0	0.0	0.0
2	-14	1.2	1.2	2.0
4	-12	2.4	2.9	4.9
6	-10	4.7	5.6	9.0
8	-8	8.3	9.7	13.7
10	-6	13.3	15.1	16.7
12	-4	20.6	20.9	16.6
14	-2	27.6	25.1	14.2
16	0	32.5	20.9	12.3
18	+2	32.2	25.1	12.5
20	+4	26.9	26.9	14.4
22	+6	19.3	26.7	16.7
24	+8	12.4	24.5	16.6
26	+10	7.5	19.8	15.5
28	+12	4.6	12.9	8.8
30	+14	2.3	8.8	4.9
32	+16	1.0	5.9	2.0
34	+18	0.0	0.0	0.0

cancelled by all diameterally appait elements. the element dB sin θ get added fall all elements, so field due to whole coil.

$$B = 2\pi R \int dB \sin\theta \doteq \frac{\mu_0}{4\pi}\int_0^{2\pi r} \frac{I\,dl}{r^2}\sin\theta.$$

$$B = \frac{\mu_0 I R^2}{2R^3\left(\frac{1+x^2}{R^2}\right)^{3/2}} = \frac{\mu_0 I}{2R\left(1+\frac{x^2}{R^2}\right)^{3/2}}$$

for N coils, $B = \dfrac{\mu_0 N I}{2R\left(\frac{1+x^2}{R^2}\right)^{3/2}}$

iii) for two coils seperate by distance 'a' then,
$OP = x_1 = (x_0 - a/2)$ for coil $- a_2$
and $a_2P = x_2 = (x_0 + a/2)$ for coil $- a_2$

x_0 = distance of point P from the center.
Point C of two when ~~$CP = x_0\ O'_2 = x_0\ O'_2 = x_0 -$~~
~~and $OP = x_0 + a/2$.~~

iv) when $x_0 - 0$ fix density has a maximum value when $a < R$ and a miniumum value when $a > h$.
The curve platted for these are shown.
when, $a = R$ the field is virtually same when.
$$\frac{-R}{2} < x < \frac{R}{2}$$

v) the special distribution of field strenghth b/w a pair of coil in the helmalR arrangement is measured. The spaing at which a uniform magnetic field is produced and

* Result :-

The graph obtained of the axid distance with respect to magnetic flux B is very close to the given graph.

* Precaution :-

i) The current and voltage must fixed to a values and should remain constant for all condition $a = R/2$, $a = R$ and $a = 2R$.

ii) The connecting wires should be connected properly and all the connection must be tight.

iii) The of both coins should lies on the same axis on which magnet is moving.

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Experiment - 4

*** Aim :-**

To determine to wavelength of laser light using diffraction grating.

*** Material Required :-**

diffraction grating of 300 lines/mm and 800 lines/mm, laser light

*** Theory :-**

i) when a wave hits an obstacles it does not simply go straight past, it bends round the obstacle. The same type of effect occur at a hole. The waves spread out the outer side of the hole. This phenomenon is called diffraction.

ii) The effect of diffraction are much more noticeable if the size of the obstacle will diffract a wave of long wavelength than a shorter one.

iii) when white light enters the grating, the light component are diffracted at angles that are determined by the respective wavelengths.

iv) By shinning a light beam into a grating whose spacing d is known and measuring the angle where the light is imaged one can measure the wavelength λ. Consider the figure which shows the setup for a diffraction grating experiment. Images of the light will appear at a number of angles - θ_1, θ_2, θ_3 and so on. Relation is given as:

$$\sin \theta_m = \frac{m\lambda}{d}$$

Teacher's Signature

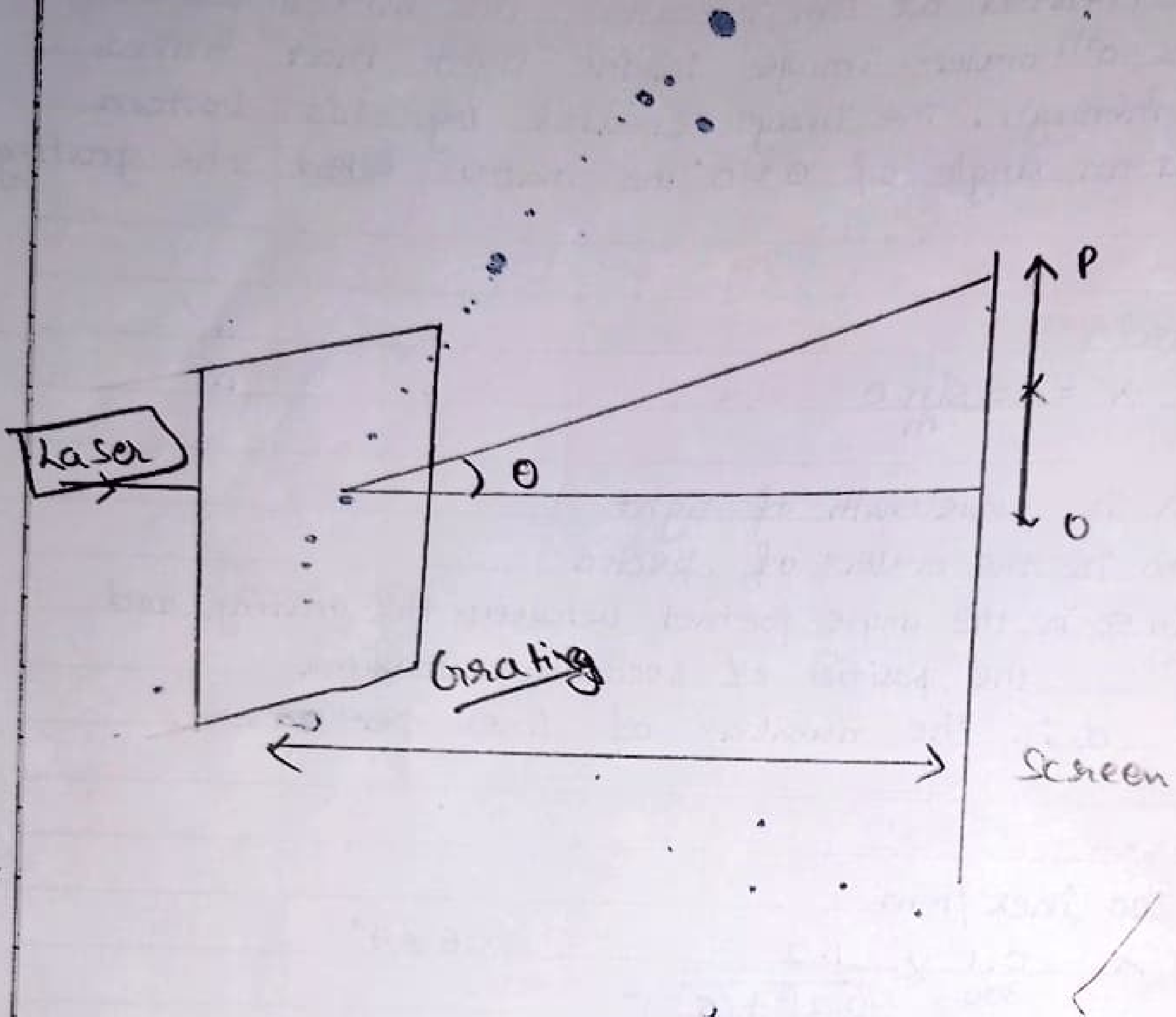
* Observation Table -

Diffraction Grating — 300 lines / mm · D = 6.5 cm

Order	Distance b/w central maxima and second maxima (cm)	λ Å (wavelength)
1.	1.2	6067
2.	2.5	5983

Diffraction Grating — 80 lines / mm · D = 23.6 cm

Order	Distance b/w central maxima and second maxima (cm)	λ Å (wavelength)
1.	1.1 cm	5516
2.	2.4 cm	6323



Laser
θ
P
x
O
Grating
Screen

v) The image created at θ_m is called the mth order image. The 0th order image is the light that shins straight through. The image created by this bottom appears at an angle of $\theta = 0°$ no matter what the grating space is.

* Formula Used:-

$$\lambda = \frac{d \sin\theta}{m}$$

where, λ is wavelength of light
m is the order of spectra
$\sin\theta$ is the angle formed between the grating and the position of secondary maxima
d is the number of lines per cm.

* Calculations:-

For 300 lines/mm

order 1 $\lambda = \frac{0.1}{300} \times \frac{1.2}{\sqrt{(1.2)^2+(6.5)^2}} = 6067 A°$

order 2 $\lambda = \frac{0.1}{300} \times \frac{2.5cm \times 1}{\sqrt{(2.5)^2+(6.5)^2}} = 5983 A°$

For 80 lines/mm

order 1 $\lambda = \frac{0.1}{80} \times \frac{1.1}{\sqrt{(1.1)^2+(23.6)^2}} = 5816 A°$

order 2 $\lambda = \frac{0.1}{80} \times \frac{2.4}{\sqrt{(2.4)^2+(23.6)^2}} = 6323 A°$

$\boxed{\lambda \text{ mean} = 6047 A°}$

Teacher's Signature

* Percentage error :-

$$\left(\frac{6250 - 6047}{6250}\right) \times 100\% = 3.20\%$$

* Result :-

The wavelength of diodelaser is 6047A°

* Precaution :-

i) The grating element and laser should be on same level along with the diode.

ii) The distance between central maxima and secondary maxima must be measured carefully.

iii) The distance between element and diode must be measured carefully on optical bench.

iv) The laser must be kept straight and should not be moved.

Teacher's Signature

Experiment - 5

*** Aim :-**

To determine the wavelength of sodium light using fresnel's Biprium.

*** Material Required :-**

Two convex lenses of fecal length 10 cm and 20 cm, fresnel biprium, eye piece, slit.

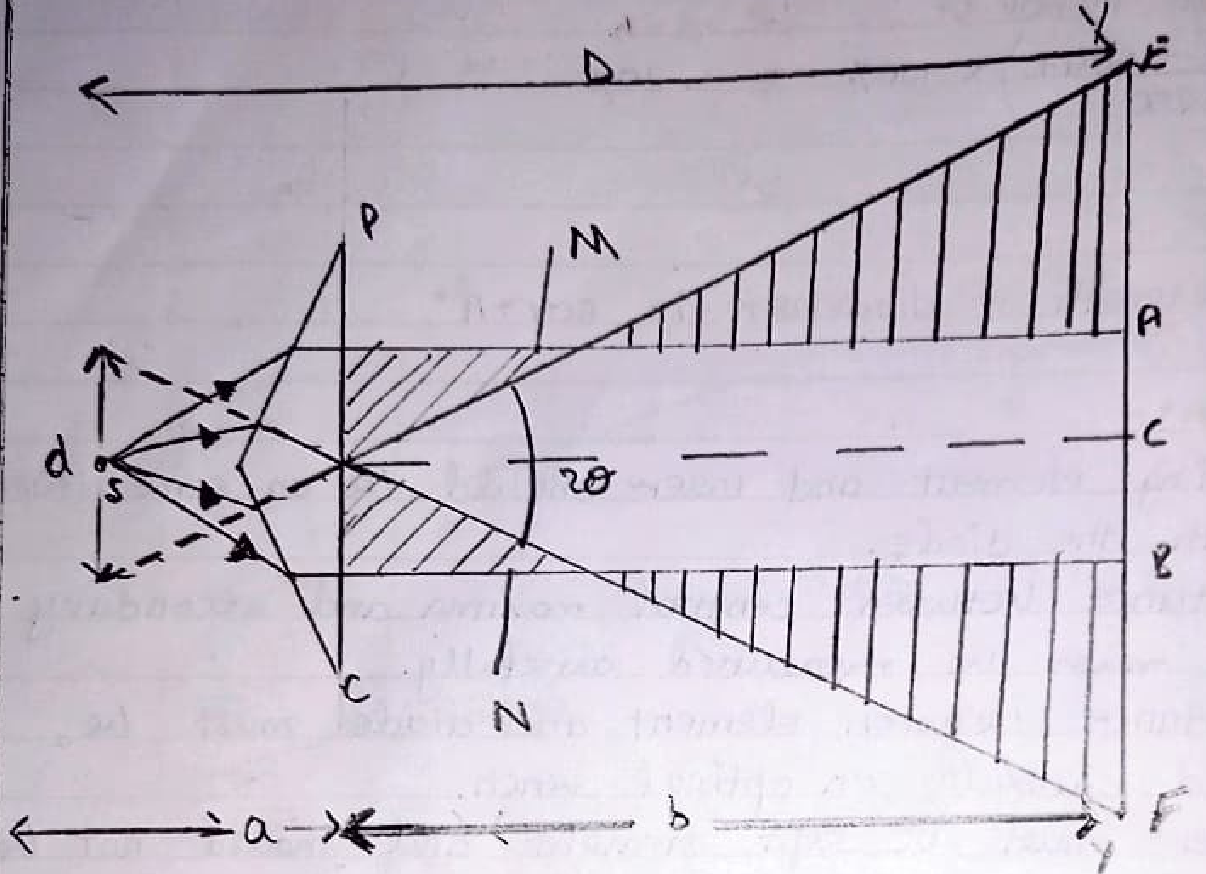
*** Theory :-**

i) Light from a monochromatics source (sodium lamp) is made to fall on a narrow vertical slit & held symmetrically and at a short distance from biprium P held with its refracting edges vertical.

ii) Each half of the biprium produces a virtual ~~edge~~ image of source of light S by refracting. The distance between S and P is so adjusted that the two virtual images S_1, S_2 of the source S lie close together.

iii) The diagram shows the horizontal cross - section of the arrangement. Thus two cohesent sources S_1 and S_2 of monochromatics light from a single source S are obtained.

iv) The point C on the screen lies at the same distance from S_1 and S_2. The two waves reaching C reforce each other and the point C will be center of a bright frings cohesent the intensity of light at any point will depend upon the path difference.


D
E
P
M
A
d
S
2θ
C
B
C
N
a
b
F

S.NO	No. of fringes	Micrometer reading (mm)	Difference (mm)	mean of diff. (mm)	fringe width (mm)
1.	n	7.335	1.14		
2.	n+6	8.475	1.11	1.133	0.189
3.	n+12	9.585	1.12		
4.	n+18	10.715	1.16		
5.	n+24	11.875			

$\beta = 0.189$ mm.

	reading for s_1 (a)	reading for s_2 (b)	b − a
d_1	0.540	7.550	7.01
d_2	−0.715	0.875	1.59

* Formula Used :-

$$\lambda = \frac{\beta d}{D}$$

where, λ is wavelength of sodium light
β is fringe width
D is distance between slit S and eye piece
d is distance between two virtual sources.

* Calculations :-

distance between two virtual sources (d) $d = \sqrt{d_1 d_2}$
$= 3.39$ mm.
$D = 106.8$ cm
$\beta = 0.189$ mm

wavelength (λ) $= \frac{\beta d}{D} = \frac{0.189}{10} \times \frac{3.39}{10} \times \frac{1}{106.8}$

$$\boxed{\lambda = 5991.6\ A^\circ}$$

* Percentage error :-

$$\left(\frac{5991.6 - 5872}{5872}\right) = \left(\frac{118.4}{5872}\right) \times 100\%$$

$= 2.02\%$

* Result :-

The wavelength of sodium lamp obtained is 5991.6 A°.

* Precautions :-

i) The slit should be very narrow and vertical.
ii) The refracting edge of the bi-prism should be made parallel to slit.

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iii) There should be no lateral shift of fringes on sliding the upright carrying the eyepeice.

iv) To avoid blacklash error, screw of the micrometer scale should be moved in some direction.

v) while measuring the fringe width, the vertical cross - wire should be made to lie at the center of bright fringe before noting the reading.

vi) for measurement of correct value of distance D index correction should be applied with proper sign.

Teacher's Signature

Experiment - 6

*** Aim :-**

To determine the moment of inertia of fly wheel about its own axis of rotation.

*** Material Required :-**

Fly wheel, stop watch, Thin cord, 100g slotted weights (5), Hanger, Meter Rod

*** Theory :-**

i) if h = vertical distance through which mass fall then P.E. = K.E. of falling mass + Rotational K.E. of wheel + work done by friction.

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + n_1 f \quad \text{------}(1)$$

where, n_1 = No. of revolutions made by the winding of cord
$n_1 f$ = Total energy spent in over coming friction after the cord leaves the axle.

ii) Let n_2 is the no. of revolutions made by wheel before coming to rest. Hence K.N. = $\frac{1}{2} I\omega^2$ of wheel is spent in over coming the friction in n_2 revolutions

$$\frac{1}{2} I\omega^2 = n_2 f$$

$$\text{or} \quad f = \frac{I\omega^2}{2n_2} \quad \text{------}(2)$$

putting 2 in 1 and rearrange we get,

$$I = \frac{2mgh - mr^2\omega^2}{\omega^2\left(1 + \frac{n_1}{n_2}\right)} \quad \text{------}(3)$$

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iii) Angular average velocity $= \left(\frac{\omega + 0}{2}\right) = \frac{\omega}{2}$

If t is the time taken by wheel before coming to rest, average velocity $\left(\frac{\omega}{2}\right)$ = total angle described in n_2 revolution.

$$\frac{\omega}{2} = \frac{2\pi n_2}{t}$$

$$\boxed{\omega = \frac{4\pi n_2}{t}} \quad \text{------ (4)}$$

(iv) If h = height through which mass m falls and is equal to length of cord wound on axle in n_1 windings s.
i.e.

$$h = 2\pi r n_1 \quad \text{------ (5)}$$

Putting 4 and 5 in equation 3 on rearranging we get

$$I = \frac{mgrn_1t^2}{4\pi n_2(n_1+n_2)} - \frac{mr^2n_2}{n_1+n_2} \quad \text{------ (6)}$$

v) From equation (6) the value of Ist term is very large as compared to the second term and so the second term is neglected. Hence,

$$I = \frac{mgrn_1t^2}{4\pi n_2(n_1+n_2)}$$

* Formula Used :-

$$I = \frac{mgrn_1t^2}{4\pi n_2(n_1+n_2)}$$

where, m is mass of weights taken
g is accelaration due to gravity
t is time taken by flywheel to come to rest.
n_1 is no. of revolutions of winding of cord.

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n_2 is total no. of revolution made by wheel before coming to rest.

* Calculations :-

$g = 980\ cm/s^2$ and $r = 1.02cm$

$$I_1 = \frac{100 \times 980 \times 1.02 \times 71^2}{4 \times 3.14 \times 60 \times 71} = 1.04 \times 10^5\ g/cm^2$$

$$I_2 = \frac{200 \times 980 \times 1.02 \times 95^2}{4 \times 3.14 \times 108 \times 119} = 1.23 \times 10^5\ g/cm^2$$

$$I_3 = \frac{300 \times 980 \times 1.02 \times 112^2}{4 \times 3.14 \times 160 \times 171} = 1.21 \times 10^5\ g/cm^2$$

$$I_4 = \frac{400 \times 980 \times 1.02 \times 132^2}{4 \times 3.14 \times 219 \times 230} = 1.21 \times 10^5\ g/cm^2$$

$$I_5 = \frac{500 \times 980 \times 1.02 \times 262^2}{4 \times 3.14 \times 262 \times 273} = 1.25 \times 10^5\ g/cm^2$$

Mean of best three values $= 1.15 \times 10^5\ g/cm^2$

* Percentage Error :-

Original value $= 1 \times 10^5\ g/cm^2$

$$\%\ error = \left(\frac{1.15 - 1}{1}\right) \times 100\% = 15\%$$

* Result :-

The moment of inertia obtained of the flywheel is about its own axis of rotation is $1.15 \times 10^5\ g/cm^2$

* Precautions :-

i) The loop should be quite loose so that it slips off the axle as soon as string has unwounded itself.

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ii) The length of the string should be little less than the height of axle above.

iii) The string should be thin and be wounded completely and uniformly on the axle.

iv) The timing and the counting of the revolution should start from the instant the mass goes off the peg.

v) There should be least possible friction at the bearing.

vi) There should be the confirmation that wheel should make about 100 revolutions before stopping.

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