Date 23-01-2022

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"Fresnels Biprism"

Aim :- To determine wavelength of monochromatic Sodium light with the help of Fresnel's biprism.

Apparatus used :- Heavy metallic optical bench with four uprights, sodium lamp, biprism, a convex lens of 10-15 cm focal length a plumb line, a bench error rod and a reading lamp.

Formula used :- The wavelength λ of monochromatic light is given by,

$$\boxed{\lambda = \frac{d}{D}\beta} \quad \text{------} \quad (1)$$

and

$$\boxed{d = \sqrt{d_1 d_2}} \quad \text{-----} \quad (2)$$

where $d = \sqrt{d_1 d_2}$ is the distance between two coherent sources,

β = fringe width

D = distance between the slit and the focal Plane of the Ramsden's eye piece.

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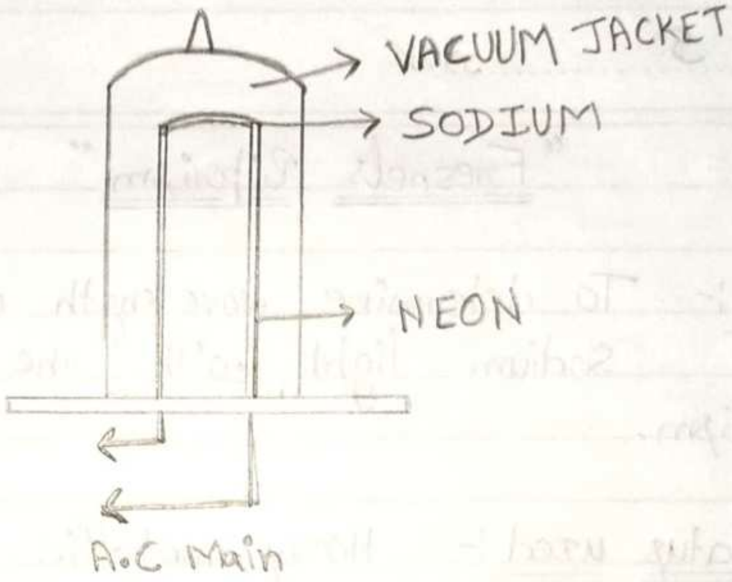
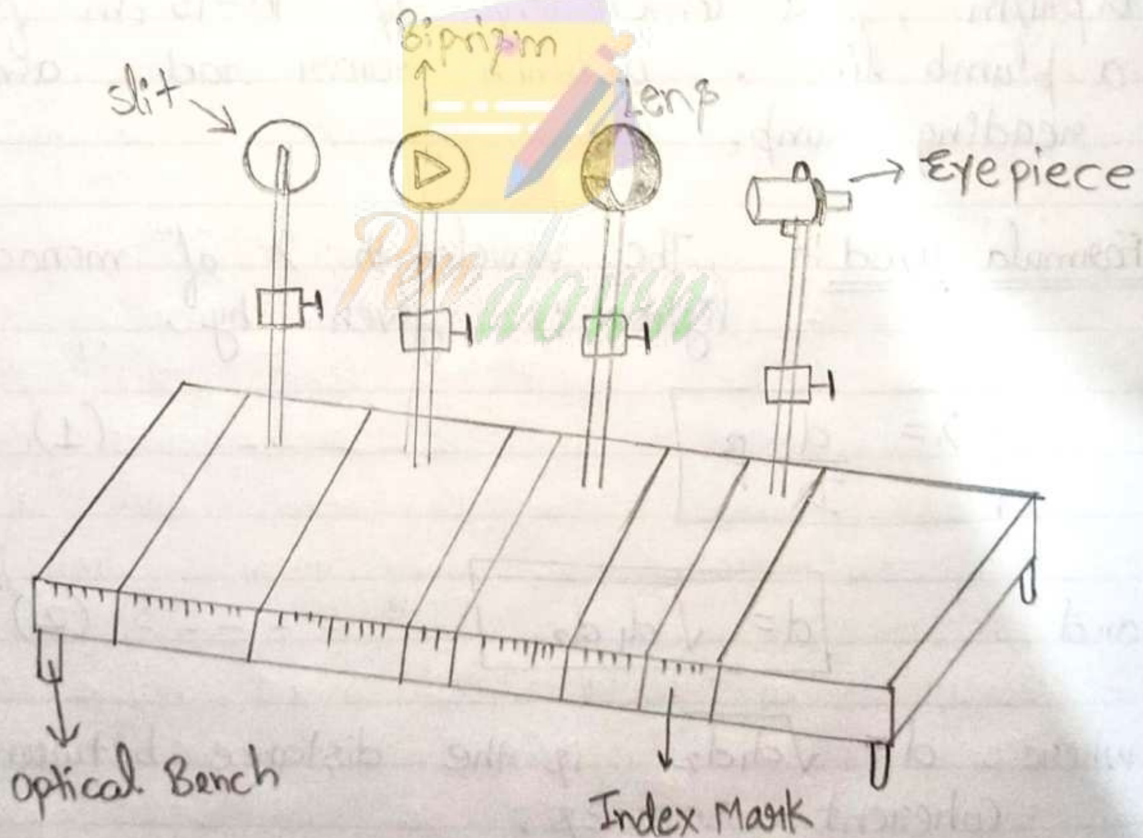
d_1, d_2 = seperation of the images of the two coherent sources formed in the focal plane of the eye piece in position I and II of the lens respectively.





Fresnel BiPrism Apparatus

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Introduction :-

Fresnel's bi-prism is used to produce two coherent sources of light by refracting through it and can be used to determine the wavelength of monochromatic source of light. Fresnel's bi-prism consists of a combination of two prism with their bases joined together and their two faces making an obtuse angle of about 179° so that the other two angles are each about 30°. The biprism is ground from a single optically plane glass plate.

Theory :- Light from a monochromatic sources (sodium lamp) is made to fall on a narrow vertical slit S held symmetrically and at a short distance from a bi-prism P held with its refracting edges vertical. The distance between S and P is so adjusted that the two virtual Images S_1 and S_2 of the source S lie close together. The Two coherent sources S_1 and S_2 of monochromatic light from a single source S are obtained as shown in fig.

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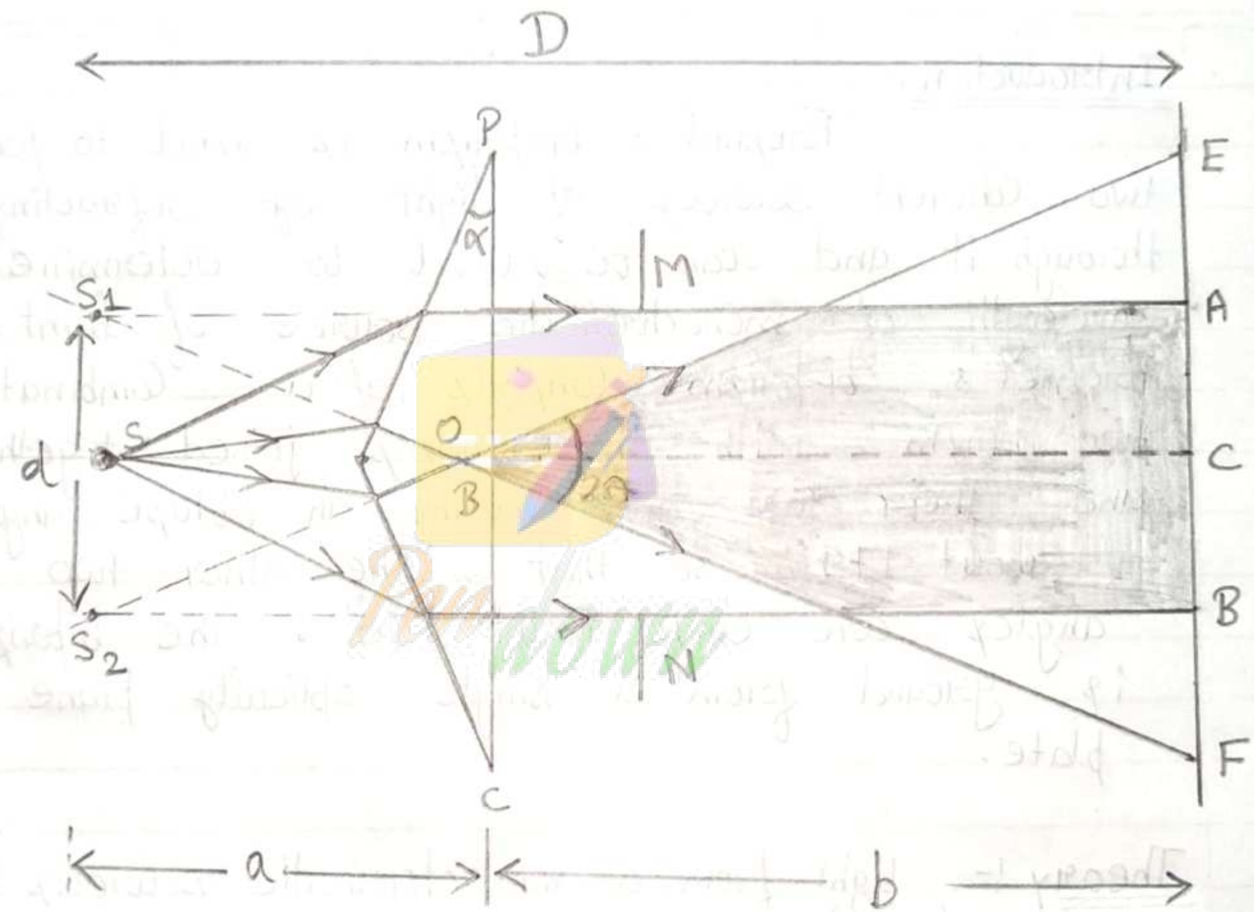
D
P
E
M
α
S_1
A
S
O
C
d
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2θ
S_2
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The wider fringes at the edges are apparently produced by the vertex of the prism, which acts as a straight edge. Since the interference fringes are narrow, they can be generally examined with the help of a low-power microscope with the fringes lying in its focal plane. The point C on the screen lies at the same distance from S_1 and S_2. The two waves reaching C reinforce each other and the point C will be the centre of a bright fringe, whereas the Intensity of light at any other point on the screen will depend upon the path difference between the optical paths of the point from S_1 and S_2 i.e. $\frac{xd}{D}$

$$\frac{x\,d}{D} = n\lambda$$ (i.e for Constructive interference.)

Therefore, $\frac{\lambda D}{d} = \frac{x}{n} = \beta$, the fringe width --(1)

Thus, if D and d are Constant, the fringe width β is proportional to the wavelength of monochromatic light. Hence, shorter wavelength fringes are narrower than the longer wavelength fringes.

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Procedure :- (i) Level the optical bench with the help of spirit level and leveling screws provided at the base.

(ii) Mount the slit and the eye piece of their uprights and switch on the sodium lamp.

(iii) widen the slit and focus the eyepiece on the Cross wires. Put a plumb line in front of the eye piece such that the thread is seen well illuminated.

Adjust by rotating the tube Containing the cross-wire so that one of the Cross wire Coincide with the plumb line. Now remove the plumb line.

(iv) Mount the Convex lens on its upright at proper height and adjust the lens upright on the optical bench so that image of the slit is formed in the plane of Cross wires.

With the help of Tangent screw, provided in the plane of the slit, slightly rotate it so that the image of the slit Coincide with the vertical Cross wire.

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(v) Mount the biprism on its upright, and adjust this upright near the slit with the refracting edge of the biprism nearly parallel to the vertical slit. Bring the eye piece near the biprism and see the patch of light in the focal plane of the eye piece. Reduce the width of the slit - slowly so that interference fringes are seen and are sharpened by giving finer rotation to the tangent screw.
After adjustment for removal of the lateral shift of the fringes is done by bringing the eye piece away and see the direction of lateral shift. The lateral shift gets removed when the axis of the optical bench and the axis of the experiment are exactly parallel.

(vi) Bring the eye piece away and fix at some-suitable distance from the biprism so that D is quite large and fringes are clearly visible. Take the observations.

(vii) Mount the convex lens and set the eye piece upright at a distance between 4f to 5f from the slit, ($f \simeq 10$ to $15\,cm$) is the focal length of the convex lens.

(viii) The Images of the two coherent sources is formed in the focal plane of the eye piece in position I and position II of the lens. Record the observations for d_1 and d_2. Take atleast 3 sets.

(ix) Now take a bench error Correction rod of length l_0 and place its two ends between the slit and the focal plane of the eye piece and note down the readings of the uprights of the slit and the eye piece on the bench, the difference will give length l.

Observations :- Least Count of the micrometer screw = 0.0005cm

T.1 Measurement of fringe width β :

order of fringe n	Micrometer Reading ms (cm)	cs (div)	Total a (cm)	order of fringe (n)	Micrometer reading ms (cm)	cs (div)	Total b (cm)	10β (b−a) (cm)	Mean 10β (cm)
Z	0.1	63	0.1315	Z+10	0.2	71	0.2355	0.1040	
Z+2	0.1	89	0.1445	Z+12	0.25	40	0.2700	0.1255	
Z+4	0.15	32	0.1660	Z+14	0.25	62	0.2810	0.1150	0.1147
Z+6	0.15	79	0.1895	Z+16	0.3	08	0.3040	0.1145	
Z+8	0.2	19	0.2095	Z+18	0.3	48	0.3240	0.1145	

Mean β = 0.01147cm

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T.2 Measurement of D: Position of slit upright, $x = 0\,cm$
Position of eyepiece upright, $y = 40\,cm$

$$D = y - x = 40\,cm.$$

□ Measurement of d, the distance between the two Coherent Sources:

S.No	Micrometer Reading for 'I' Position of Lens						$d_1 = b - a$ (cm)
	Image (S_1)			Image (S_2)			
	MS (cm)	CS (div)	Total a (cm)	ms (cm)	cs (div)	Total b (cm)	
1.	0.60	61	0.6305	0.70	42	0.7210	0.0905
2.	0.65	26	0.6630	0.70	83	0.7415	0.0785
3.	0.65	84	0.6920	0.75	27	0.7635	0.0715

S.No	Micrometer Reading for 'II' Position of Lens							$d = \sqrt{d_1 d_2}$ (cm)	Mean (d) (cm)
	Image (S_1)			Image (S_2)			$d_2 = e - c$ (cm)		
	ms (cm)	cs (div)	Total c (cm)	ms (cm)	cs (div)	Total e (cm)			
1.	0.35	23	0.3615	0.8	08	0.8040	0.4425	0.2001	
2.	0.35	58	0.3790	0.8	45	0.8225	0.4435	0.1865	0.1882
3.	0.35	81	0.3905	0.8	70	0.8350	0.4445	0.1782	

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Bench error Correction :-

Length of bench error rod, $l_0 = 40$ cm

On placing the two ends of the rod between the slit and the focal plane of the eye piece

position of the slit, $P = 0$ cm
position of the eye piece, $q = 40$ cm

$$l = q - P = 40 \text{ cm}$$

bench error $= l - l_0 = 0$ cm

Corrected $D = D - (l - l_0)$
$= 40 - 0$
$D = 40$ cm

Calculations :-

$d = 0.1882$ cm, $D = 40$ cm
$\beta = 0.01147$ cm

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

$$\lambda = \frac{0.1882}{40} \times 0.01147 \times 10^{-2} \text{ m}$$

$$\lambda = 5.3966 \times 10^{-7} \text{ m} = 5396.6 \text{ Å}$$

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<u>Result</u> :- The wavelength of sodium yellow light determined is = 5396.6 Å

<u>Precautions</u> :- (i) Light incident through the slit must be adjusted parallel to the optical bench.

(ii) All the uprights must be adjusted at the same height.