To determine the wavelength of a monochromatic source of light with the help of Fresnel’s biprism.

Manual as a Part of B. Tech- (1yr) Physics Laboratory
1 Objective
To determine the wavelength of a monochromatic source of light with the help of Fresnel’s biprism.

2 Apparatus (See Fig. 1)

1. Optical bench
2. Biprism
3. Slit
4. Micrometer eye-piece
5. Monochromatic source of light (sodium lamp)
6. Convex lens

3 Formula Used
The wavelength $\lambda$ of the sodium light is given by the formula in case of biprism experiment.

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

where $\beta =$ fringe width i.e., the distance between two successive maxima or minima of the fringes, $d =$ distance between the two virtual sources ($=S_1S_2$), $D =$ distance between the slit and screen or eye-piece where the fringes are observed and measured.

4 Theory
Suppose that the monochromatic light from a slit $S$, perpendicular to the plane of the paper, falls symmetrically on the biprism, the refracting edge of which is perpendicular to the paper. The edge $B$ of the biprism divides the incident wave-front into two parts which passing through the upper half and the lower-half of the biprism appear to diverge from the virtual images $S_1$ and $S_2$. These two images now serve as the two coherent sources produced from the
same source and are very close to and equidistant from S. Consequently, interference fringes are observed on the overlapping region of the two emergent beams of light (Figure 2).

![Diagram](image)

**Fig. 2**

The wavelength of monochromatic source of light can be calculated by the formula

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

where $\beta$ = fringe width i.e., the distance between two successive maxima or minima of the fringes, $d$ = distance between the two virtual sources ($=S_1S_2$), $D$ = distance between the slit and screen or eye-piece where the fringes are observed and measured.

### 5 Procedure and Observations

1. The bed of the optical bench is levelled by a spirit level and the levelling screws.
2. Light source and slit is arranged in order to get the maximum light incident on the slit.
3. The centre of slit, biprism and eye piece is arranged at same height as shown in Figure 1.
4. The slit and biprism edge are made vertical and in line parallel to the bench.
5. Observe the interference fringes with eye piece. For clear fringe pattern adjust the edge of biprism by rotating screw.
6. If the line joining the slit and the central edge of the biprism is not parallel to the length of the bench, fringes would shift laterally as the eye-piece is moved. To remove this, the biprism is moved a small distance transversely to the bench in a direction opposite to the direction of the shift till this lateral shift vanishes (Figure 3).
7. Now measure the position of fringes by putting the cross wire at mid position of each bright fringe.
8. For measurement of $d$, a lens of short focal length is inserted between the slit and the eye-piece.
9. The eye-piece is moved away from the slit so that the distance between the slit and the eye-piece is greater than four times the focal length of the convex lens used for the measurement of ‘d’.

**Measurement of β**

The cross-wire is set at the centre of the first bright fringe and the reading of the micrometer screw is taken. The screw is then moved in one direction so that the wire falls in succession at the centers of the bright fringes and the corresponding readings are taken. From these readings, the width of a number of fringes (say, 10) are calculated by subtracting the first fringe from eleventh, second from twelfth and so on. After taking the mean, fringe width β for one fringe is calculated.

![Measurement of β](image3.png)

**Measurement of d**

Without changing the position of the slit, biprism and the eye-piece; a convex lens is mounted on the optical bench between the latter two. The distances $d_1$ and $d_2$ between the well-defined images of the two virtual slits $S_1$ and $S_2$ are measured with the micrometer screw for the two positions of the lens as shown in (Figure 4). Then the distance between $S_1$ and $S_2$ is given by

$$d = \sqrt{d_1d_2}$$

If the convex lens is not well chosen, the distance $d_2$ between the images of the slit in the second case (giving diminished images) becomes very small and the measurement become too erratic.
To avoid this, the distance ‘u’ between the lens and the slit and ‘υ’ between the lens and the eye-piece in the first case giving magnified images is measured. Then

\[
d / d_1 = u / v \text{ or } d = (u / v) \times d_1
\]

**Measurement of D**

The position of the slit and the eye-piece are noted. The distance between them gives observed value of D.

**Table 1: Reading for the measurement of β**

Pitch of the screw = …. cm.

No. of divs. on the circular head = …. 

Least count of the micrometer screw = …. cm.

<table>
<thead>
<tr>
<th>No. of fringes</th>
<th>Micrometer reading (in cm)</th>
<th>No. of fringes</th>
<th>Micrometer reading (in cm)</th>
<th>Separation of 10 bands (in cm) (b-a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>11.</td>
<td>11.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>12.</td>
<td>12.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>15.</td>
<td>15.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>16.</td>
<td>16.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>17.</td>
<td>17.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>18.</td>
<td>18.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>20.</td>
<td>20.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
[B] Readings for the determination of d

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Micrometer readings when lens is near the slit (in cm)</th>
<th>$d_1 = d - c$ (in cm)</th>
<th>Micrometer readings when lens is near the eye-piece (in cm)</th>
<th>$d_2 = d' - c'$</th>
<th>$d = \sqrt{(d_1d_2)}$ (in cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st image $c$</td>
<td>2nd image $d$</td>
<td>1st image $c'$</td>
<td>2nd image $d'$</td>
<td></td>
</tr>
</tbody>
</table>

[C] Readings for the determination of D

<table>
<thead>
<tr>
<th>Position of the slit (in cm) $x$</th>
<th>Position of eye-piece (in cm) $y$</th>
<th>Position of lens near the biprism (in cm) $z$</th>
<th>$u$ (z-x) (cm)</th>
<th>$v$ (y-z) (cm)</th>
<th>$D$ (y-x) (cm)</th>
<th>$(u / v) \times d_1$ (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* These columns should be added if the distance $d_2$ between the two images of $S_1$ and $S_2$ is too small to be measured. In that case the latter half of the table [B] should not be used.

6 Result

Mean fringe width for one fringe = ….cm

Value of D = …. cm.

$\lambda = \beta d / D = \ldots \ldots \AA$.

The wave length of the monochromatic source = (…………… ± Maximum probable error) Å.

7 Precautions

1. The setting of uprights at the same level is essential.
2. The slit should be vertical and narrow.
3. Crosswire should be fixed in the center of the fringe while taking observations for fringe width.
4. The micrometer screw should be rotated only in one direction to avoid backlash error.
5. The fringe width should be measured at a fairly large distance.
6. Convex lens of shorter focal length should be used ($f = 25$ cms. approx.)
7. Motion of eyepiece should be perpendicular to the lengths of the bench.
8. Appendix

Apparatus

The biprism consists of two prisms, each of very small refracting angle (of the order of 1° or even less than 1°) placed base to base. In practice, the biprism is constructed from a single plate of glass by suitable grinding and polishing, the obtuse angle of the prism (which is only slightly less than 180°).

The optical bench consists of two metal rails graduated accurately in millimeters. The bench is provided with the three metal uprights which can slide along the rails and their positions can be read accurately by scale attached to each of them. The uprights can also be given transverse displacement with the help of a screw. The top portions of the uprights carrying the biprism and the slit can be rotated about an axis parallel to the optical bench. The third upright carries a Ramsden’s eye-piece. By means of rack and pinion arrangement the uprights can be moved vertically and adjusted to suitable heights. A spare upright without rack and pinion arrangement, is given to mount the lens.

Ramsden’s eye-piece: A cross-wire or a line scratch made on a glass piece is fitted at some distance in front of the field lens of this eye-piece. It is provided with a divided circular head reading a very small least count. The eye-piece can be moved at right angles to the length of the optical bench by giving rotations to the screw.

The whole arrangement has been shown in Figure 1.