Name: [illegible] ID: [illegible]

Section: G Group: 01 Trimester: Spring 25 Date of Submission: ______

*Experiment No. 01*

**Name of the Experiment: Determination of the refractive index of a liquid by plane mirror and pin method using a convex lens.**

## Theory:

If a convex lens is placed on a few drops of liquid on a plane mirror, then on squeezing the liquid into the space between the mirror and the lens, a Plano-concave liquid lens is formed. The curved surface of this liquid lens has the same radius of curvature as the surface of the lens with which it is in contact. Thus we have a combination of two lenses – one of glass and the other of liquid, which behaves as a convergent lens. If F be the focal length of the combination, then we have the relation

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2} \quad \dots\dots\dots (1)$$

where $f_1$ and $f_2$ are the focal lengths of the convex lens and the liquid lens respectively.

Correcting for the sign of $f_2$ which is negative, we get

$$\frac{1}{F}=\frac{1}{f_1}-\frac{1}{f_2}$$

$$\frac{1}{f_2}=\frac{1}{f_1}-\frac{1}{F} \quad \dots\dots\dots (2)$$

Determining F and $f_1$ experimentally, we can calculate $f_2$ from relation (2).

The focal length of the plano-concave liquid lens is also given by relation

$$\frac{1}{f_2}=(\mu-1)\left(\frac{1}{r}-\frac{1}{r'}\right)=(\mu-1)\frac{1}{r}$$

($r' = \infty$, the lower face of the liquid lens being a plane)

According to sign convention, both $f_2$ and r are negative. Thus,

$$\mu = 1+\frac{r}{f_2} \quad \dots\dots\dots (3)$$

Where $\mu$ is the refractive index of the liquid.

Finding r, the radius of curvature of the lower surface of the convex lens i.e. the surface in contact with the liquid, and knowing $f_2$ from relation (2), the refractive index of the liquid, $\mu$ can be found out by using relation (3).

Note: The radius of curvature of the surface of the lens is given by,

$$r=\frac{a^2}{6h}+\frac{h}{2}$$

## Apparatus:

- A convex lens
- A plane mirror
- Pin/pointer with its tip painted
- Spherometer
- Slide calipers
- Stand
- Some experimental liquid (water or glycerin)

## Experimental Data:

(A) Measurement of h

| Reading on | No. of obs. | LSR, x (cm.) | CSD | LC (cm.) | Value of CSR, y=LC×CSD (cm.) | Total reading, x+y (cm.) | Mean (cm.) |
|---|---|---|---|---|---|---|---|
| Base plate | 1 | 0 | 1 | 0.001 | 0.001 | 0.001 | 0.006 |
| | 2 | 0 | 11 | | 0.011 | 0.011 | |
| | 3 | 0 | 8 | | 0.008 | 0.008 | |
| Lens surface | 1 | 0.2 | 16 | | 0.016 | 0.016 | 0.213 |
| | 2 | 0.2 | 9 | | 0.009 | 0.009 | |
| | 3 | 0.2 | 15 | | 0.015 | 0.015 | |

h = Reading on lens surface – Reading on the base plate = 0.207 cm

Measurement of 'a': Mean value of a = $\frac{a_1+a_2+a_3}{3}$ = 3.833 cm

Therefore, radius of curvature of the spherical surface, $r = \frac{a^2}{6h}+\frac{h}{2}$ = 11.93 cm

(B) Table for the thickness of convex lens t

| No. of obs. | MSR, x (cm.) | VSD | Vernier Constant, VC (cm.) | Value of VSR, y=VC×VSD (cm.) | Total reading, x+y (cm.) | Mean thickness (cm.) | Instru-mental Error | Correct thickness t (cm.) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.8 | 15 | 0.005 | 0.075 | 0.875 | 0.87 | 0 | 0.87 |
| 2 | 0.8 | 13 | | 0.065 | 0.865 | | | |
| 3 | 0.8 | 14 | | 0.07 | 0.87 | | | |

(C) Determination of the focal lengths

| No. of obs. | Distance between the pin and the face of the lens (without the liquid), $h_1$ (cm.) | Focal length of the convex lens, $f_1 = h_1 + \frac{t}{3}$ (cm.) | Mean $f_1$ (cm.) | Distance between the pin and the face of the lens (with the liquid), $h_2$ (cm.) | Focal length of the combination, $F = h_2 + \frac{t}{3}$ (cm.) | Mean F (cm.) | Focal length of the liquid lens, $f_2 = \frac{Ff_1}{F - f_1}$ (cm.) |
|---|---|---|---|---|---|---|---|
| 1 | 10.4 | 10.69 | | 15.9 | 16.19 | | |
| 2 | 10.8 | 11.09 | 10.89 | 15.7 | 15.99 | 16.156 | 93.41 |
| 3 | 10.6 | 10.89 | | 16.0 | 16.29 | | |

**Calculation:**

$\therefore \mu = 1 + \frac{r}{f_2} = 1.357$

**Result:**

The refractive index of the given liquid is, $\mu =$ 1.357

**Discussions:**

Q: What is refractive index? Write down the refractive index of water and compare (% difference and % accuracy) your result.

The refractive index is a measure of how much a material slows down the speed of light compare to the speed in a vaccum. Refractive index of water is 1.33. My experimental result is 1.357

Difference (%) = $\frac{|1.357 - 1.33|}{1.33} = 0.0203 \times 100\% = 2.7\%$

Accuracy = $100\% - 2.7\% = 97.3\%$

Q: What is the physical significance of refractive index?

The physical significance of the refractive index lies in its ability to describe how light interacts with different media. It determines the speed of light in the medium and the degree of bending as light enters or exists the medium.

Q: What is the speed of light through the liquid whose refractive index you have determined?

We know that

$$\mu = \frac{C_o}{C_m} \qquad \mu = 1.357, \quad C_o = 3\times10^8\ ms^{-1}$$

$$\Rightarrow C_m = \frac{C_o}{\mu} = \frac{3\times10^8\ ms^{-1}}{1.357}$$

$= \cancel{2\times21}$

Speed of light $= 2.21\times10^8\ ms^{-1}$ through the liquid

Q: What is radius of curvature? Is it possible to find the refractive index of the given liquid without using a spherometer?

The radius of curvature is the distance from the center of curvature to the surface of a curved lens or mirror.

Yes, the refractive index of a liquid can be determined without a spherometer by measuring critical angle of light passing from the liquid to air. Using Snell's law, the refractive index can be calculated from the critical angle without needing to measure the curvature of surfaces.

Q: Calculate the Least Count of the given spherometer.

$$\text{Least count, LC} = \frac{\text{Pitch}}{\text{Number of divisions on the CS}}$$

$$= \frac{1\ mm}{100}$$

$$= 0.01\ mm$$

$$= 0.001\ cm$$