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EXPERIMENT-1

Refractive index of a liquid by measuring the real and apparent depth of an object using a traveling microscope

Aim: To determine the refractive index of a liquid.

Apparatus: Traveling microscope (L.C = 0.001 cm), Slap of glass, Water Beaker

Theory: Refraction is the bending of light rays as it moves from one medium to another of different optical density. Normal shift is defined as the difference between actual depth and apparent depth and it is caused due to refraction of light.

Working Formula-

$$r.i\ (\mu) = \frac{Real\ depth\ of\ object}{Apparent\ depth\ of\ object} = \frac{d_3 - d_1}{d_3 - d_2}$$

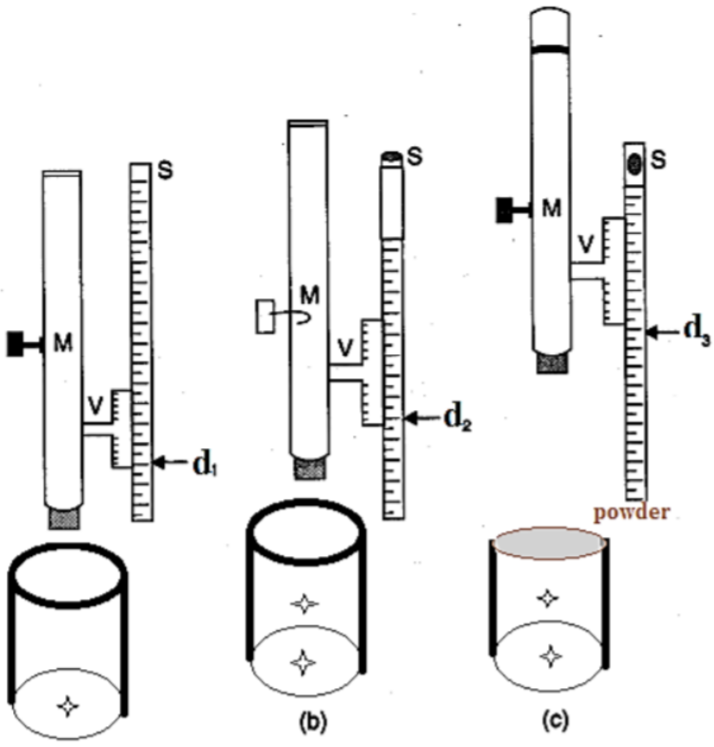


Fig. Real and apparent thickness.

Observations:

Table-1: Determination of d_1

Sl.no.	M.S.R (cm)	V.S.R	TOTAL d_1 (cm)
01	03	36	3.036
02	03	73	3.073
03	03	15	3.015

Table-2: Determination of d_2

Sl.no.	M.S.R (cm)	V.S.R	TOTAL d_2 (cm)
01	4.3	95	4.395
02	4.3	25	4.325
03	4.2	38	4.238

Table-3: Determination of d_3

Sl.no.	M.S.R (cm)	V.S.R	TOTAL d_3 (cm)
01	8.2	18	8.218
02	8.2	84	8.284
03	8.3	22	8.322

Table-4

Vernier constant of traveling microscope is 0.001cm.

Sl. No.	d_1 (cm)	d_2 (cm)	d_3 (cm)	Real depth (d_3-d_1) cm	Apparent depth (d_3-d_2) cm	$r.i\ (\mu) = \frac{d_3 - d_1}{d_3 - d_2}$	Mean (μ)
01	3.036	4.395	8.218	5.182	3.823	1.355	1.323
02	3.073	4.325	8.284	5.211	3.959	1.316	
03	3.015	4.238	8.322	5.307	4.084	1.299	

Error Analysis:

Working Formula-

$$r.i\ (\mu) = \frac{Real\ depth\ of\ object}{Apparent\ depth\ of\ object} = \frac{d_3 - d_1}{d_3 - d_2}$$

$$ln\mu = ln(d_3 - d_1) - ln(d_3 - d_2)$$

Differentiating the above equation, we get-

$$\frac{\Delta\mu}{\mu} = \frac{\Delta(d_3 - d_1)}{d_3 - d_1} - \frac{\Delta(d_3 - d_2)}{d_3 - d_2}$$

For maximum error-

$$\frac{\Delta\mu}{\mu} = \frac{2\Delta d}{d_3 - d_1} + \frac{2\Delta d}{d_3 - d_2}$$

$\Delta d = 0.001cm$

For case-1, $d_3 - d_1 = 5.182cm$ and $d_3 - d_2 = 3.823cm$

The error is $\frac{\Delta\mu}{\mu} = \frac{2(0.001)}{5.182} + \frac{2(0.001)}{3.823} = 9.091 \times 10^{-4}$

∴, the percentage error in μ is 0.09091%

For case-2, $d_3 - d_1 = 5.211cm$ and $d_3 - d_2 = 3.959cm$

The error is $\frac{\Delta\mu}{\mu} = \frac{2(0.001)}{5.211} + \frac{2(0.001)}{3.959} = 8.8898 \times 10^{-4}$

∴, the percentage error in μ is 0.088898%

For case-3, $d_3 - d_1 = 5.307cm$ and $d_3 - d_2 = 4.084cm$

The error is $\frac{\Delta\mu}{\mu} = \frac{2(0.001)}{5.307} + \frac{2(0.001)}{4.084} = 8.665767 \times 10^{-4}$

∴, the percentage error in μ is 0.08665767%

∴, The average percentage error in μ is $\frac{0.09091+0.088898+0.08665767}{3}$

∴, The average percentage error in μ is 0.08882189%

$$\frac{\Delta\mu}{\mu} \times 100 = 0.08882189\%$$

$$\frac{\Delta\mu}{\mu} = 0.08882189 \times 10^{-2}$$

$$\Delta\mu = 0.08882189 \times 10^{-2} \times \mu$$

The average mean of refractive index is μ= 1.323

$$\Delta\mu = 0.08882189 \times 10^{-2} \times 1.323 = 1.175 \times 10^{-3}$$

$$\Delta\mu = 0.001175 \approx 0.001$$

∴, The refractive index of the given liquid is (1.323 ± 0.001)

Results:

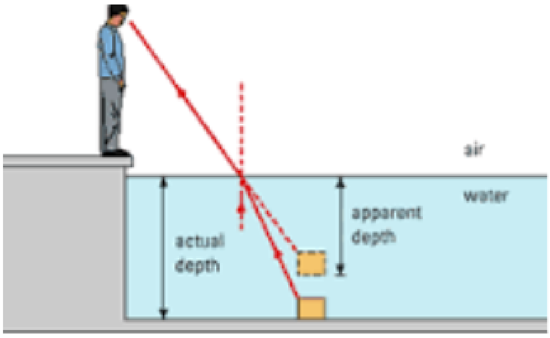
1. The refractive index of the given liquid is (1.323 ± 0.001)
2. The average percentage error in μ is 0.08882189%

Precaution:

1. Make sure the beakers can be filled right to the top with water.
2. Care must be taken when measuring the distances.
3. Make sure your line of view is perpendicular to the surface of the medium.
4. Zero error must be noted in the measuring instruments.
5. To avoid backlash error, the microscope should be moved upward.
6. To reduce statistical error in measurements, at least 3-5 readings must be taken.
7. Parallax and back-lash errors during measurement must be avoided.

Discussion:

1. Real and Apparent Depth-



Here in this example, **Real Depth** is actual distance of an object beneath the surface, as would be measured by submerging a perfect ruler along with it.
Apparent depth in a medium is the depth of an object in a denser medium as seen from the rarer medium. Its value is smaller than the real depth.

$$D_{\text{apparent}} = \frac{D_{\text{real}}}{\mu}$$

2. When we look down into a pool of water from above, the pool looks less deep than it really is. Figure I.6 shows the formation of a virtual image of a point on the bottom of the pool by refraction at the surface.

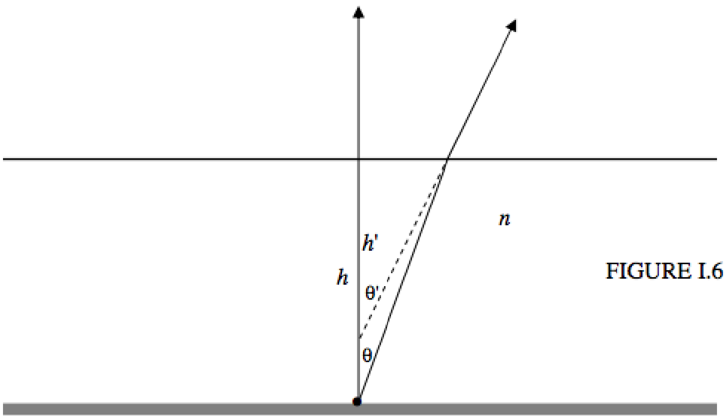


FIGURE I.6

The diameter of the pupil of the human eye is in the range 4 to 7 mm, so, when we are looking down into a pool (or indeed looking at anything that is not very close to our eyes), the angles involved are small. Thus in Figure I.6 all the angles are considered small. Since angles are small, Snell's law can be approximated-

$$n = \frac{\sin\theta'}{\sin\theta}$$

$$\approx \frac{\tan\theta'}{\tan\theta}$$

$$\frac{\text{real depth}}{\text{apparent depth}} = \frac{h}{h'} = \frac{\tan\theta'}{\tan\theta} = n.$$