Apparent Depth

Purpose

Using "Borderless Lab 365" platform to measure the real and apparent depths of a refracting block.

Theory

- In a homogenous and isotropic medium, the light rays emitted by an object travels to observer in a straight line. Thus, rays of light can be regarded as streams of particles emitted from a source of light and traveling in straight lines.
- When a ray of light is traveling across an interface dividing two uniform media of different optical density, part of the light rays will be refracted. The direction of the refraction ray is affected by the **refractive indices** of the two media, following by Snell's Law.
- When we look down into a pool of water from above, the pool looks less deep than it really is. The following figure (Fig. 1) shows the formation of the virtual image of a point on the bottom of the pool by refraction at the surface.

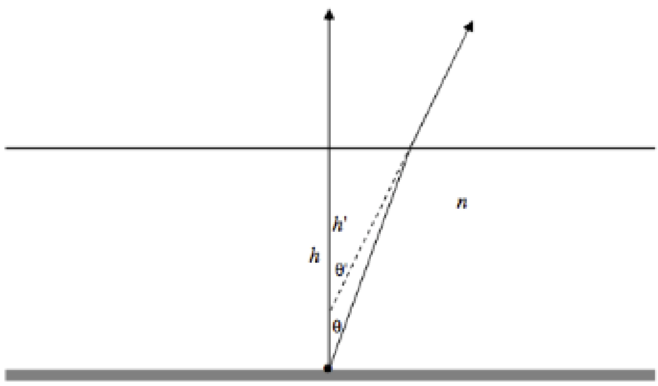

Fig. 1

From the Snell's Law, we have

$$n \sin\theta = 1 \sin\theta'$$

The diameter of the pupil of the human eyes is in the range of 4 to 7 mm, when we are looking down into the pool (or indeed looking at anything that is not very close to our eyes), the angle involved are small. For small angle, we can approximate $sin\theta \approx tan\theta$. Thus, we can obtain n = h/h' = real depth/apparent depth.

- The refractive index of the medium can be found by measuring the real and apparent depths of an object. In this experiment, a travelling microscope will be used to form clear image under different circumstances.
- The first reading to be measured is the distance of the microscopic lens from the object for clear image formation. The second reading is taken with a block of unknown refracting index to be measured, then the apparent depth of the object will be calculated. The third reading is taken with the object on top of the refracting medium where a clear image is formed, this data will allow you to obtain the real depth of the block. (Fig. 2)

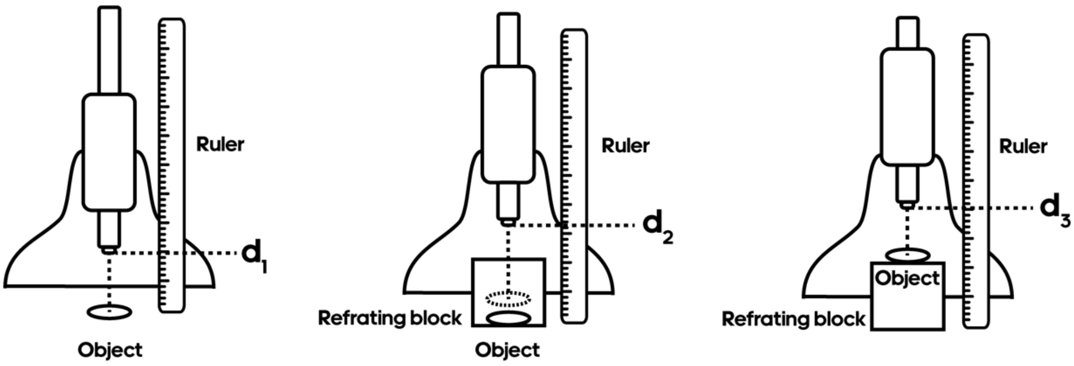

Fig. 2

- The real thickness of the block d_{real} is given by $d_3 - d_1$.
- The apparent thickness of the block d_{app} is given by $d_3 - d_2$.
- The refractive index of the block is therefore $n = \frac{d_{real}}{d_{app}} = \frac{d_3 - d_1}{d_3 - d_2}$.

Apparatus

- “Borderless Lab 365” Platform
- Traveling microscope, plastic block and black object.

Procedure

1. Log in the experiment module “Apparent Depth” on the Borderless Lab 365 platform. https://stem-ap.polyu.edu.hk/remotelab/
2. Choose “Position A” on the right of the control panel.
3. Press the “Up/Down” buttons to adjust the traveling microscope until the image of the object (black spot) is clearly focused.
4. Press the “Measure” button at the bottom left corner to record the magnitude of d_1.
5. Lift the traveling microscope to a level such that “Position B” can be chosen, where the refracting block can be placed between the object and the microscopic lens.
6. Repeat Step 3 and 4 to find out the magnitude of d_2.
7. Choose “Position C” to focus another object (another black spot) on top of the refracting block. Repeat Step 3 and 4 to find out the magnitude of d_3.
8. From the data obtained in the table, determine the real and apparent thickness of the refracting block, followed by its refractive index.

Data

Position	**Reading (mm)**
Position A / d_1	
Position B / d_2	
Position C / d_3	
	Magnitude
Thickness of the block d_{real} $= d_3 - d_1$	
Apparent thickness of the block d_{app} $= d_3 - d_2$	
Refractive index of the block $\boldsymbol{n = \frac{d_{real}}{d_{app}} = \frac{d_3 - d_1}{d_3 - d_2}}$	

Discussion

1. Can you tell how much did the refracting block "lift up" the image of the object?

2. Why is the thickness of the refracting block equal to $d_3 - d_1$?

3. Why is the thickness of the refracting block equal to $d_3 - d_2$?

4. What are the possible errors of the experiment?

5. A thicker block or a thinner block will improve accuracy? Why?

6. What is the magnification of the image?