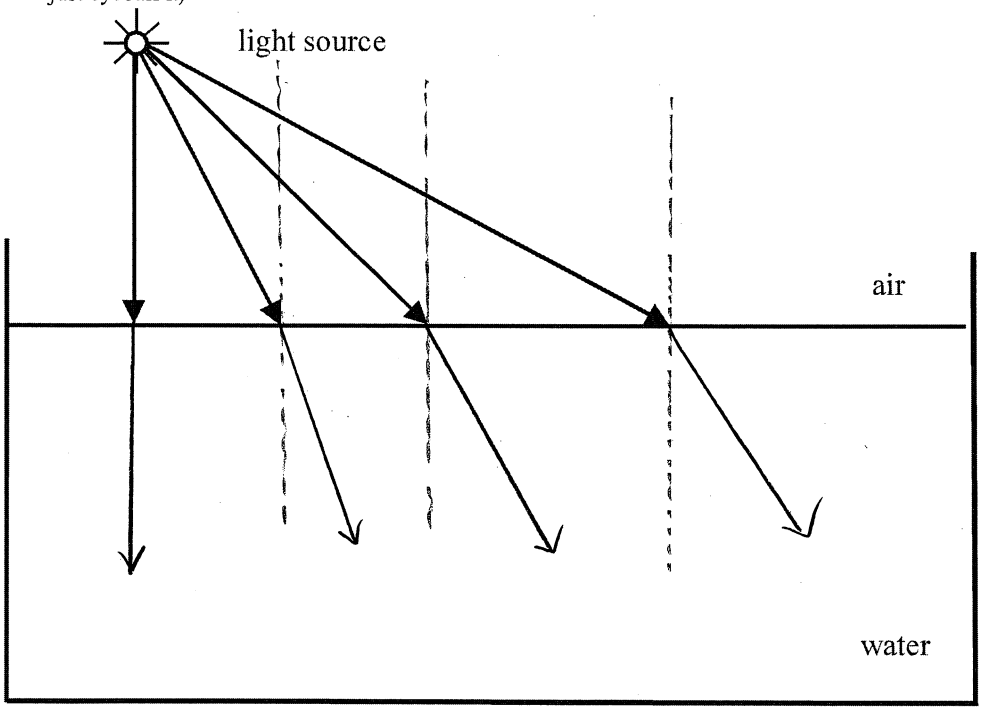
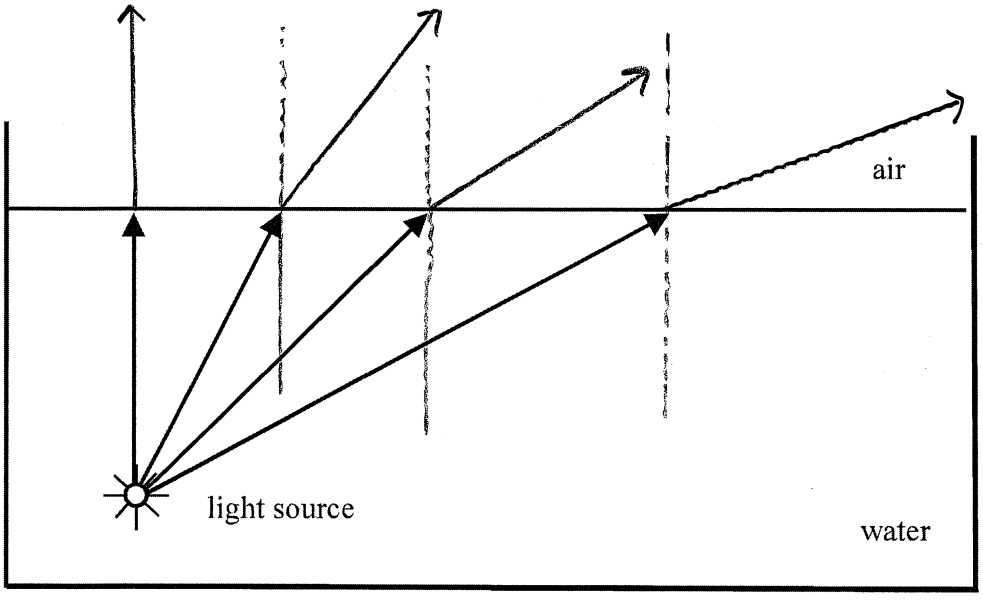
Refraction Worksheet

1. Sketch the path of the rays showing the refraction at the air/water boundary. Include the normal for <u>each</u> ray and a correct location of an observer's eye in the water that could see <u>each</u> ray. (no calculations, just eyeball it)



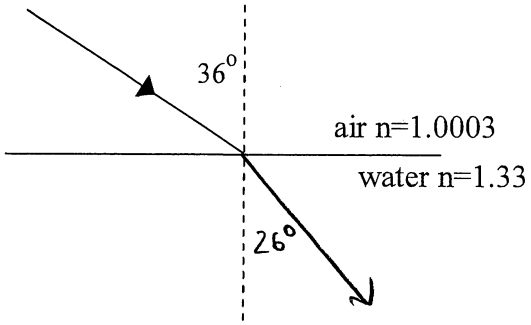
angle is smaller

2. The light source is now under water. Sketch the path of the rays as they pass from the water into the air. Include the normal for <u>each</u> ray and a correct location of an observer's eye in the air that could see <u>each</u> ray. (no calculations, just eyeball it)



angle is bigger

3. Use the Law of Refraction to determine the direction of the refracted ray. Sketch (eyeball) the refracted ray and label the angle.



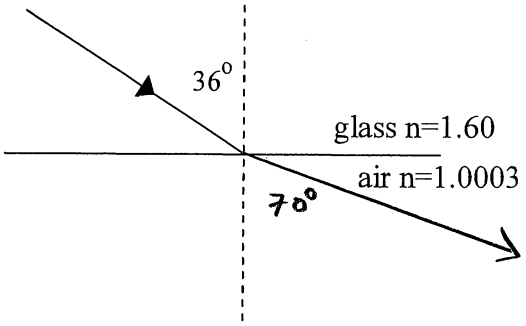
$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

$$\frac{\sin 36}{\sin\theta_2} = \frac{1.33}{1.0003}$$

$$\sin\theta_2 = \frac{1.0003 \sin 36}{1.33}$$

$$\theta_2 = 26^\circ$$

4. Use the Law of Refraction to determine the direction of the refracted ray. Sketch (eyeball) the refracted ray and label the angle.



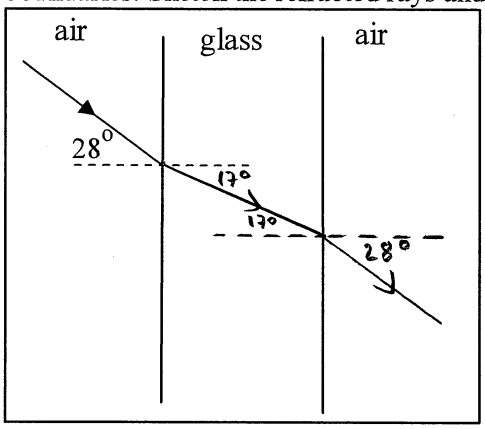
$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

$$\frac{\sin 36}{\sin\theta_2} = \frac{1.0003}{1.60}$$

$$\sin\theta_2 = \frac{1.60 \sin 36}{1.0003}$$

$$\theta_2 = 70^\circ$$

5. a) Use the Law of Refraction to determine the direction of the refracted ray through the 1st and the 2nd boundaries. Sketch the refracted rays and label the angles. Assume the boundaries are parallel.



air/glass

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

$$\frac{\sin 28}{\sin\theta_2} = \frac{1.60}{1.0003}$$

$$\sin\theta_2 = \frac{1.0003 \sin 28}{1.60}$$

$$\theta_2 = 17^\circ$$

glass/air

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

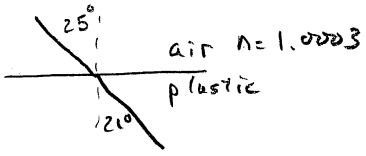
$$\frac{\sin 17}{\sin\theta_2} = \frac{1.0003}{1.60}$$

$$\sin\theta_2 = \frac{1.60 \sin 17}{1.0003}$$

$$\theta_2 = 28^\circ$$

b) Sketch (eyeball) the reflected rays above.

6. In a lab experiment where light passes from air into a plastic block, the incident angle is measured to be 25° and the refracted angle is 21°. Find the index of refraction for the block.

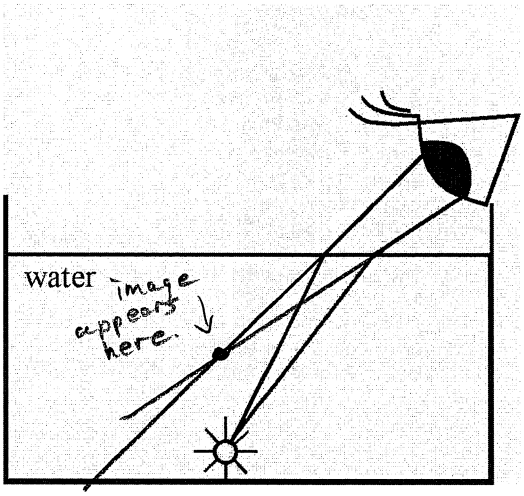


$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

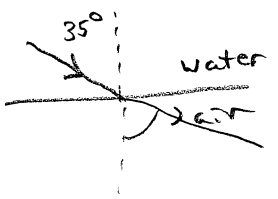
$$\frac{\sin 25}{\sin 21} = \frac{n_2}{1.0003}$$

$$n_2 = \frac{1.0003 \sin 25}{\sin 21} = 1.18$$

7. a) Locate the position of the image of the underwater light source as seen by the eye.



b) If one of the light rays in the tank of water hits the surface at 35° as measured from the normal, at what angle will it enter the air? ($n_{water} = 1.33$)



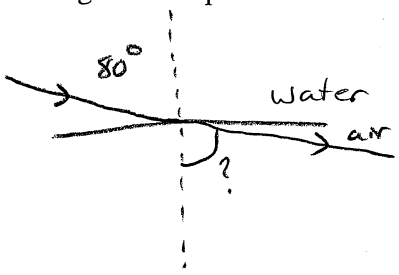
$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

$$\frac{\sin 35}{\sin\theta_2} = \frac{1.0003}{1.33}$$

$$\sin\theta_2 = \frac{1.33 \sin 35}{1.0003}$$

$\theta_2 = 49.7 \simeq 50°$

c) Now suppose the incident angle in the water is 80° as measured from the normal. What is the refracted angle? What problem arises?



$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

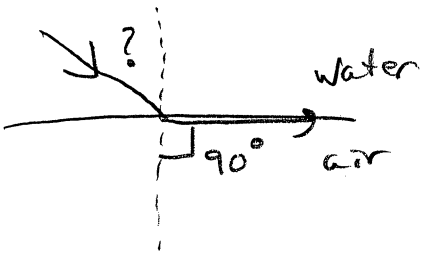
$$\frac{\sin 80}{\sin\theta_2} = \frac{1.0003}{1.33}$$

$$\sin\theta_2 = \frac{1.33 \sin 80}{1.0003}$$

$\sin\theta_2 = 1.309$

- impossible
- θ_2 does not exist.
- the light won't be refracted.

d) Find the critical angle for the water-air interface (this is the incident angle that corresponds to the largest possible refracted angle, 90°).



$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

$$\frac{\sin\theta_1}{\sin 90} = \frac{1.0003}{1.33}$$

$$\sin\theta_1 = \frac{1.0003 \sin 90}{1.33}$$

$\theta_1 = 48.7 \simeq 49°$