Workshop Tutorials for Introductory Physics

WI6: **Reflection and Refraction**

A. Review of Basic Ideas:

Use the following words to fill in the blanks:
refracted, speed, rays, reflected, reflection, transmitted, shallower, incidence, bends, perpendicular

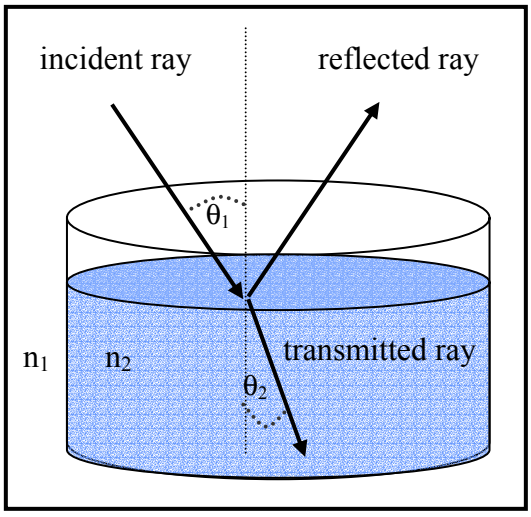
Reflection and Refraction of Light

When you look into the surface of a swimming pool, often you can see both the bottom of the pool and your own _____. When light hits any surface, in this case the surface of the water, there is usually some light reflected, some light absorbed and some which is _____ into the underlying medium. To see your reflection, light reflected from you must have bounced or reflected off the surface. To see the bottom of the pool some light has travelled through the air-water interface to the bottom of the pool where again some light is reflected and the rest absorbed. The _____ light then passes back up through the water – air interface and into your eyes.

You may also have noticed that swimming pools always look _____ than they really are. To understand why this is we use the laws of reflection and refraction of light and we model light as _____ travelling in straight lines. Imagine a line perpendicular to the water-air interface at the point of incidence of the incoming ray. The angle between the perpendicular and the incident ray (the angle of _____) and the angle between the perpendicular and the reflected ray (the angle of reflection) are equal. This is the law of reflection.

The law of refraction, which tells us how light _____ as it moves from one medium to another, is defined in terms of a quantity known as the refractive index.

The refractive index of a material depends on the _____ of light in that material. It is the ratio of the speed of light in a vacuum to the speed of light in the medium and so is always greater than 1. Once again imagine a line perpendicular to the water-air interface at the point of incidence of the incoming ray. The angle of incidence, θ_1, is the angle between the incident ray and the _____. The angle of refraction, θ_2, is the angle between the perpendicular and the _____ ray in the new medium (water in this case). Call the air medium 1, with refractive index n_1 and water medium 2 with refracrive index n_2. The law of refraction states that $n_1 \sin\theta_1 = n_2 \sin\theta_2$. The greater the ratio of n_2 to n_1, the more the light will bend when it enters medium 2.



B. Activity Questions:

1. Prism

Shine the light through the prism.
What do you see going into the prism?
What do you see coming out?
Which is refracted (bends) more – light of long or short wavelength?
Sometimes after rain or when there is a break in the clouds you may see a rainbow. On a sunny day if you stand with the sun behind you , you can make a rainbow by spraying a mist of water from a hose.
Draw a diagram showing how the rainbow is formed by the droplets of water.

2. Bent pencil
Why does the pencil appear to be bent?
Draw a diagram showing how the light is bending in this case.

3. Losing your marbles
Pour the liquid into the container with the marbles in it.
Why do they appear to disappear?
What can you conclude about the refractive index of the marbles and the liquid?

4. Total internal reflection
Shine the light into the cable.
Can you see the light through the sides of the cable?
Where is the light going, and why?

C. Qualitative Questions:

1. Have you ever noticed that swimming pools and rock pools by the ocean seem shallower than they actually are? Inexperienced snorkelers sometimes try to reach out and grab fish drifting past, believing them to be much closer than they actually are.
Consider an object lying on the bottom of a swimming pool. Draw a diagram the path of a light ray coming from an object at the bottom of a swimming pool into your eye. Use your diagram to explain why the object seems closer than it really is.

2. It is possible to see the sun or even a distant boat on the ocean when it is below the physical horizon. Explain, using a diagram, how this is possible.

D. Quantitative Question:

The picture below shows a fish and the fisherman who is hoping to catch him. It is a calm clear day and the surface of the water is perfectly smooth. The refractive index of water is 1.33.
a. What is the critical angle for the air-water interface?
b. Draw a diagram showing what the fish sees.