Practice Problems Section 15 Solutions

1. A beam of light consisting of two different frequencies traveling through air strikes a glass interface and is subsequently **refracted** by it. The incident beam of light makes an angle of 41° with the normal at the air-glass interface. Once refracted in the glass, the beam of light separates. One frequency is refracted at 39° and the other frequency is refracted at 30°.
2. What are the indices of refraction for these two frequencies of light in this glass? **Show your work!**

In both cases, we use Snell’s law to find the index of refraction.

For frequency 1 (the 39° frequency), we find

and for the 30° frequency we find

1. Assume the two incident frequencies are red (incident frequency Hz) and blue (incident frequency Hz). Which color gets refracted at 39° and which color gets refracted at 30°? **Briefly explain.**

**The blue is the 30° frequency and the red is the 39° frequency**. We know this because of the idea of dispersion. Dispersion holds that high frequencies travel slower in a material than lower frequencies. Thus, the blue light should travel slower than the red light, which means it should have a higher index of refraction.

1. Find the frequency, wave speed and wavelength of the blue light inside the glass. **Show your work!**

When a light wave (or any wave, for that matter) goes from one medium to another, its frequency does not change. The frequency depends only on the source of the wave, not on what medium it is in. Thus,

Since the index of refraction of the blue light is known, we can find the wave speed.

Finally, we can use these results to find the wavelength,

m/s

1. A beam of light is traveling inside a solid glass cube that has an index of refraction of 1.60. It strikes the surface of the cube from the inside.
2. If the cube is in air, what will be the minimum angle with respect to the normal that the light can strike the boundary and not enter the air?

This is asking about total internal reflection (i.e. when the light wave does not refract at all). The minimum angle for total internal reflection is called the critical angle, and occurs when the refracted ray makes a 90° angle with respect to the normal. Thus,

1. What would be the minimum angle if the cube were immersed in water instead of air?

If the cube were immersed in water, then the expression to find the critical angle would be

1. In which medium is there a larger range of angles for which total internal reflection will occur? Explain.

A far greater range of incident angles will occur in air (specifically 38.7° to 90° in air compared to 56.2° to 90° for water). This makes sense because the bending of the light will be more extreme going from the class to air than from the glass to water, simply because the speed of light changes by a greater factor.

Thus, with a greater bending of light, there are more incident angles for which the light either bends to 90° or cannot bend at all into the second medium.