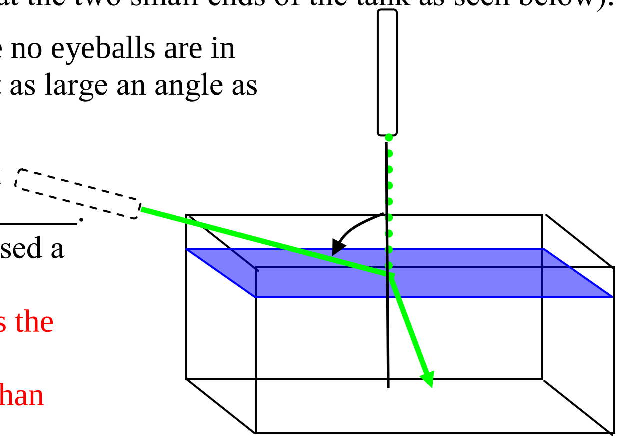
PHYS 1053 **Optics & Telescopes** **Name: Answers .**

Reflection & Refraction, Stars pages 37-38 **(Dark Room)**

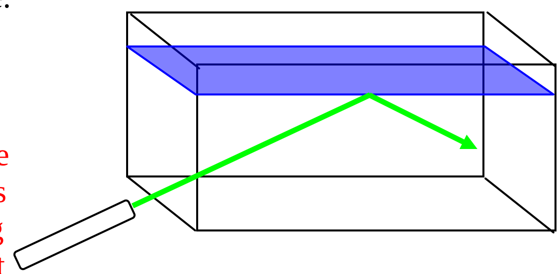
Be Careful with the Laser!! This laser, pointed into an eyeball, can do serious permanent damage (and you won't feel a thing). Remember that the beam will reflect and/or refract off any surface it hits. Make sure no eyeballs are in dangerous positions (above the water's surface, or at the two small ends of the tank as seen below).

Start with the beam vertical, as shown at right. Then, making sure no eyeballs are in the way, rotate the laser so the beam hits the water's top surface at as large an angle as possible. (This is the "angle of incidence" mentioned in the text.)



On the figure, **sketch** what happens to the beam (dashed line) as it enters the water in this case. This is an example of __**refraction**______. Also **sketch** in a line perpendicular to the water's surface. If we used a red laser instead of green, what would you expect to be different? Moving from air into water, the beam of green light bends towards the perpendicular. The red beam would bend slightly less, since the wavelength is longer. (As the text says, "green is refracted more than red.")

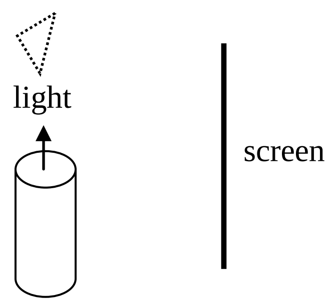
Now aim the laser into the water from the side, towards the top surface. **Sketch** the path of the beam within the water for this situation on the figure shown at right. This is an example of __**reflection**_______.



Why do you think it is easier to see the laser beam when it is in the water than when it is in the air? There are more particles in the volume of water than in an equal volume of air, so there are more opportunities for the light to be scattered in random directions as a result of colliding with particles. Thus, less of the beam arrives in the small spot where it is aimed, and more of it arrives at your eye.

Dispersion, Stars pages 36 & 39 **(Dark Room)**

Set up the light as shown in the bird's eye view at right. (The line of white light should not be pointed at the screen.) Hold the prism as shown and try to get a spectrum to land on the screen. What order are the colors in? (infrared), red, orange, yellow, green, blue, (indigo), violet, (ultraviolet) (or "ROY G. BIV")



Which color is "bent" the most? (That is, which one appears toward the bottom of the page in the diagram at right?) the bluer the light (shorter wavelengths), the more it bends (refracts).

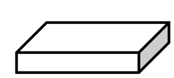
Now put down the prism and try the diffraction grating. How many separate spectra can you get to appear simultaneously? The point is to see that you get more than one spectrum (rainbow). You may have seen a brighter one and a fainter one, or a pair of brighter ones bracketed by a pair of fainter ones. In a very dark room it is sometimes possible to see an even fainter third pair around the middle two pairs. With a brighter light source, even more copies of the same rainbow can be seen.

Lastly, hold the CD at an angle in the light beam and look for rainbows. Why does the CD also produce a spectrum? A CD is made by etching lots of fine grooves in a reflective surface, so it works just like the diffraction grating, which is just a whole bunch of fine lines etched in glass.

More Refraction (*only if you have time at the end*)

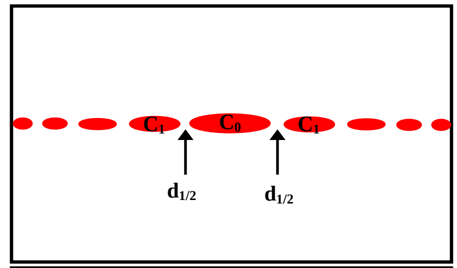
Take a flat glass rectangle and hold it flat size up (like a square frisbee). Look through the skinny clear side at your finger held vertically on the other side. Change the angle of the glass slightly by rotating in the plane (like spinning a frisbee on your finger). What happens to the image of your finger as you rotate the glass? Why?

The part of your finger behind the glass looks displaced from the rest of the finger, because the glass is refracting the light beams passing through it. Rotating the block of glass is like changing the angle of the pen laser as it entered the water: the closer the beam comes to skimming the surface, the more it will bend when it enters the water.



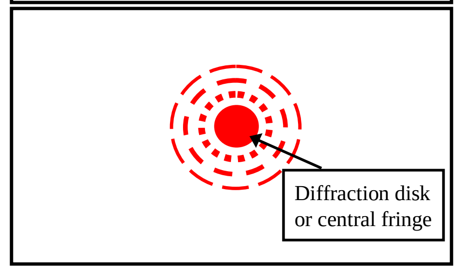
Diffraction, Stars pages 38-39 **(Dark Room)**

With the laser off, use the flashlight to read the labels on the notched wheel. Turn on the laser with the slider switch on its back. **Be careful not to hit any eyeballs!** Rotate the wheel so the laser passes through the skinny end of the "variable slit" option. Slowly rotate the wheel to the fat end of the slit, watching what happens to the pattern, then **sketch** in the upper box the final pattern you see on the screen. (Walk closer to the screen to see faint details!)



Compare this with the diagram on p. 39 of the text, and **label the locations of c_o**, both **c_1**, and both **$d_{1/2}$** on your sketch.

Now rotate the wheel so the laser passes through the larger "circular aperture" option, and **sketch** what you see in the lower box.



Read the paragraph about resolution and diffraction on pages 42-43 of the text, then **label** the "central fringe" (or "diffraction disk") in your sketch.

Doppler Effect, Stars page 40 **(on computer)**

Light and sound are both waves, so they both exhibit the Doppler effect. First go to http://www.walter-fendt.de/ph11e/dopplereff.htm and watch the ambulance pass the pedestrian.

Is the frequency of the sound waves arriving at the pedestrian higher or lower after the ambulance has passed?

As the ambulance recedes from the pedestrian, the pitch becomes lower corresponding to a lower frequency.

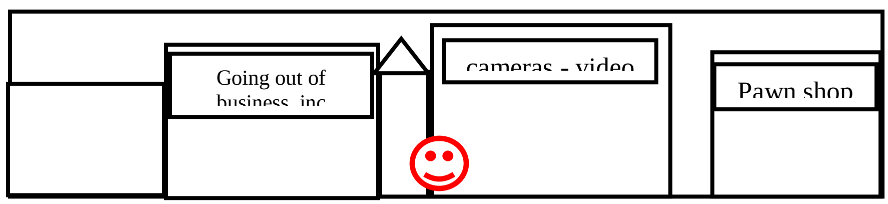
Is the wavelength heard by the pedestrian longer or shorter after the ambulance has passed?

As the ambulance recedes from the pedestrian, the wavelength of the sound wave grows longer.

If this were light instead of sound, would the light be redder or bluer after the ambulance has passed?

Longer wavelengths and lower frequencies correspond to redder light.

Now go to http://www.colorado.edu/physics/2000/applets/doppler2.html. *(Try not to absorb the social commentary while listening to the sound - it's the only site I can find with sound!)* Listen to the car go by and figure out roughly where you must be standing in the picture based on the change in the sound. **Mark** your location in the sketch at right. (Somewhere in the middle.)



If you were inside the car as it moved, how would the sound be different? The Doppler effect only happens when the source is moving relative to the observer (or vis versa). If you are moving with the car as it makes the noise, you will hear the siren, but it won't change pitch because it isn't approaching or receding (Neither the length of the waves nor the frequency of their arrival are changing for you.)

Build a Refractor, Stars pages 40-44

Hold the lens in the black frame at arms length so you can see the eye chart through it. Hold the larger unframed lens ("A") near your eye and sight through it to the framed lens, then move it in and out until the eye chart comes into focus. Repeat this experiment with the smaller unframed lens ("B"). Consult p. 41 of the text to help answer the following questions.

Which "eyepiece" lens gives more magnification, A or B? B (the one with the shorter focal length.)

Which eyepiece lens has a longer focal length? A (the one with less magnification & larger field of view)

Which eyepiece is harder to line up properly to see through (this means it has a smaller field of view)? B

Examine a Reflector, Stars pages 45-46

Look into the barrel of the telescope from both ends. Compare what you see with the diagrams by the telescope and those in your text.

What is the name for this telescope design? Cassegrain (or Schmidt-Cassegrain, because of the lens at the front.)