Assignment 3; Phys 186 Name ______________

1. (20 points) A large refractive index lens on eyeglasses has $n \approx 1.7$, compared to about 1.5 for ordinary glass. Imagine that you read a website that says:

> You will never find glasses with lenses using a material with $n \geq 2$ due to total internal reflection. For such a large index of refraction, the critical angle beyond which light rays from air cannot enter the glass and are totally reflected back is relatively small. This severely restricts peripheral vision, and thus such materials are not suitable to make lenses for eyeglasses.

Does this seem correct, or is it yet another example of the sort of nonsense you can find on the web? Whatever your answer is, support it with a *quantitative* argument.

2. (30 points) You pass white light through a prism, and see the ray of light split into a rainbow pattern. Choose between four possible explanations:

(a) The prism is a diffraction grating, with the spaces between atoms acting as slits.

(b) The prism is a double slit, with the spaces between atoms acting as slits.

(c) The prism has a index of refraction n that depends on the wavelength λ, with n increasing as λ increases.

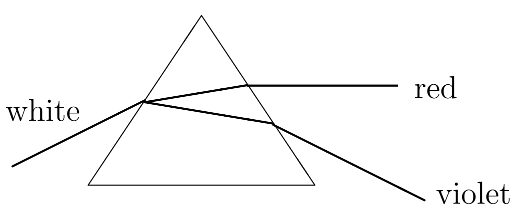
(d) The prism has a index of refraction n that depends on the wavelength λ, with n decreasing as λ increases.

Explain how each of the following is relevant to your decision:

- Atoms in a crystal such as the prism are separated by distances around 1 nm.

- No white light gets through; only the rainbow pattern is seen.

- Red light appears at the top, violet at the bottom:



3. (50 points) You have an electric dipole arranged on the x-axis: a $+q$ charge at $x = +a$ and a $-q$ charge at $x = -a$. The charges are connected by a rigid rod, so the distance between them never changes.

(a) Calculate the electric field created by this dipole on a point on the x-axis, for $x > a$. Get both magnitude and direction.

(b) Calculate the force the first dipole exerts on another dipole further down the x-axis. Get both magnitude and direction.

(c) You now have the second dipole oriented perpendicular to the first:

Qualitatively sketch the forces on this second dipole due to the first dipole. Also indicate in what direction (clockwise or counterclockwise) it rotates. Very briefly explain why.

(d) What can you conclude about dipole-dipole interactions from this problem? Do dipoles attract or repel one another? How do they orient themselves relative to each other?

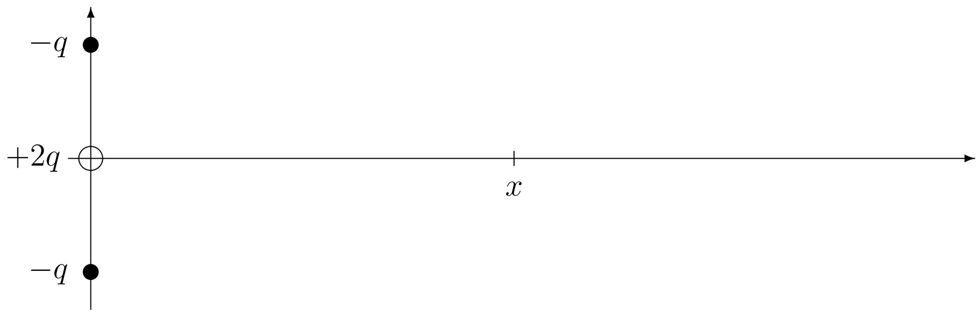
Extra Problems (not graded)

4. (0 points) If you dive down under water on a bright sunny day and you look up, you will see the whole sky within a circle on top of you, with darkness on the sides.

(a) Explain what is happening. (Looking up an online explanation is fine, but make sure what you write here is *only* in terms of what we discussed in class.)

(b) Let's say you're at a depth d below the surface. Express the radius r of the circle of light in an equation that might depend on d and anything else you think is necessary.

5. (0 points) You have charges $-q$ at $x = 0, y = a$ and $x = 0, y = -a$, and a charge $+2q$ at $x = 0, y = 0$. The positions of the charges are fixed.



(a) Find the total electric field at a point a distance x from the origin on the x axis. In other words, find the total E_x and E_y as functions of k, q, a, and x.

(b) If you can cast your previous answer in a form that puts all the a-dependence in a term that goes like $(1 + a^2/x^2)^{-3/2}$, you can use the approximation

$$\left(1 + \frac{a^2}{x^2}\right)^{-3/2} \approx 1 - \frac{3a^2}{2x^2}$$

valid for $a \ll x$. Use this to show that for large x values, the electric field goes like $E \propto x^{-4}$, an inverse fourth power law. (Ask me for math help if you need it.)