Physics 123 section 2 CID ____________

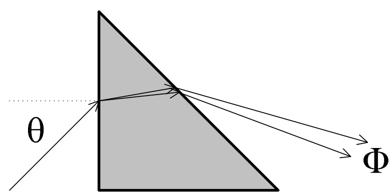
Homework 25

Score ________ / 30

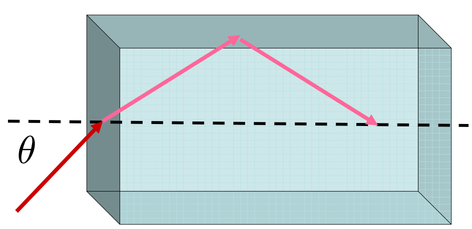
1. (4 pts) Prove that light passing through a thick slab of glass with parallel surfaces comes out the other side traveling in the same direction as it came in.

2. (5 pts) A narrow beam of white light hits a block of fused quartz at an angle of 42.2 degrees from the normal of the surface. What is the angular width of the beam inside the quartz? The index of refraction of quartz is 1.47 for violet light, and 1.458 for red light. By angular width, I mean the spread in angles of the different colors of light, i.e. the angle between the color of light which bends the least and the color of light which bends the most.

3. (6 pts) Light passes through a 45-45-90 degree prism made out of flint glass as shown in the figure below. If a beam of white light enters the prism at an angle of θ=20 degrees from the normal, what is the angle Φ between exiting red and violet components of the beam? The index of refraction for flint glass is 1.62 for red light and 1.66 for violet light.



4. (5 pts) A rectangular block of ice is sitting on the ground. A beam of ice traveling horizontally enters one face of the ice at an angle θ from the normal. The transmitted beam then strikes the front face of the ice block, as shown in the figure below. What is the maximum angle θ which will result in total internal reflection off of the front surface of the ice. The index of refraction for ice is 1.309.



5. (6 pts) A lifeguard is sitting 10 meters from a shoreline which runs from east to west. A swimmer which is 15 meters to the west and 20 meters to the north of the lifeguard starts to struggle. The lifeguard can run at a speed of 6.3 m/s and can swim at 1.7 m/s. (a) What direction (what angle relative to due north) should the lifeguard start running to get to the swimmer as fast as possible? (b) Show that your result obeys Snell's law. Hint: You will get a transcendental equation (i.e., one which can't be solved algebraically for the thing you want to find). The way to get an answer is to solve for t as a function of the point where she reaches the water, x. Then plug in trial values of x to find which one gives the smallest time. If you have a graphing calculator, or if you know how to use Maple, Mathematica, or MatLab, these can be helpful for this problem. It can be done without too much trouble, however, with any scientific calculator. (If you are interested, there is a free program which is similar to MatLab. It is called "Octave." You can read more about it on my home page.)

6. (4 pts) An optical fiber is made of a core which is 2 microns in diameter with an index of refraction of 1.7, covered by a cladding with an index of refraction of 1.5. Calculate the radius of the smallest cylinder you could wrap the fiber around without destroying total internal reflection at the core/cladding interface and allowing light to leak out of the fiber core and into the cladding.

Extra problems I recommend you work (not to be turned in)

- If you stick a pencil half way into a glass of water at an angle, the pencil appears to be bent. Why?
- Derive Snell's law from Fermat's principle.
- Derive Snell's law from Huygens's principle.
- I shine a laser beam at the wall and mark the location where it hits the wall. I then put a piece of glass with parallel surfaces into the beam between the laser and the wall. If my glass has a thickness d and an index of refraction n, and the laser beam hits the glass at an angle θ from normal incidence, how far will the spot on the wall move? (Hint, it WILL move — even though the laser comes out of the glass traveling in the same direction, it comes out displaced from where it would have been if it hadn't gone through the glass.)