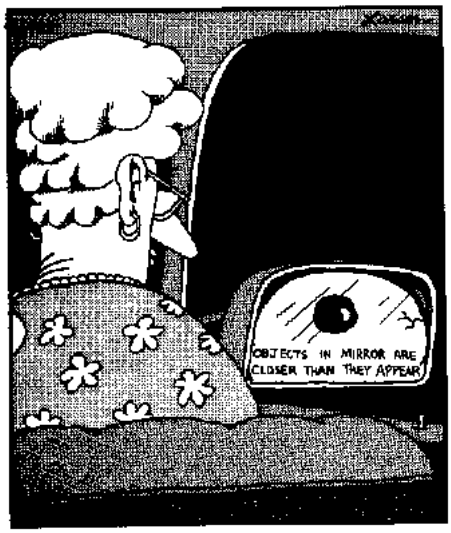
Physics 4L Spring 2010 — Problem set 1
Due Tuesday 26 January in class



From Wolfson: Chapter 30 problem 36 (the flashlight beam comes out of the water some distance from the edge of the lake; the figure for problem 37 gives you an idea of the geometry, except you are not right at the edge of the water.)

Chapter 30 problem 54.

Additional problems:

1. Rearview mirrors on cars are curved rather than flat so that the image is reduced and you can view a larger area. You can form a reduced image with either a diverging (convex) or a converging (concave) mirror; why are only diverging (convex) mirrors used as rearview mirror? Justify your answer with ray diagrams.

2. What type of mirror, diverging (convex) or converging (concave), is used as a magnifying mirror? Does such a mirror always produce a magnified image? Is the magnified image real or virtual? Justify your answer with ray diagrams.

3. Blue and red laser beams traveling through the air strike a flat slab of glass with incidence angle 50°. The index of refraction for the glass is 1.680 for the blue light and 1.621 for the red light. Will either beam undergo total internal reflection in the glass? Justify your answer. Find the angle at which each beam exits the glass if it does.

4. The chambered nautilus considered in class has a region of photosensitive tissue 1 cm in diameter. (a) How close can the nautilus get to the 1-m tall seaweed and still view a complete image of the seaweed if the nautilus's pinhole is 1 cm in front of the photosensitive tissue? (b) If you assume that the same amount of light still goes through the pinhole, does the image get brighter or dimmer as it gets larger?

Self-test problem appears on the next page.

Please also complete a short electricity and magnetism diagnostic test online, due Sunday, Jan. 31 at 8 p.m. (please complete it *before* reading any of Wolfson Ch. 20). As with the mechanics test, this diagnostic test will help me know how much background the class has on these topics. However, I fully expect that many of you have very little or no background in this subject, so don't worry at all if you find that you are completely unfamiliar with the material on the test!

From the link to the E&M test on the Assignments web page, log in with:
username = student password = Physics4L

You will receive full credit (equivalent to three homework problems) if you answer all of the questions, regardless of whether your answers are correct. If the question deals with unfamiliar material, choose the answer that seems most plausible to you. You may skip questions 18, 28, 29, and 31 (we won't cover those).

Lab-related material: In addition to the problem set, some problems and questions are assigned as part of the preparation for the lab, which you do in your lab notebook. You'll probably find it convenient to work on these while working on the problem set. This week, you can also work ahead of time with a study group on the ray tracing exercises at the end of the first lab, if you prefer that to doing them in lab.

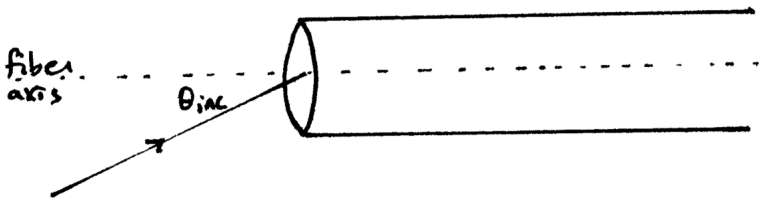
Not required but highly recommended: Try to review the material from the first class the same day or the next day (Tuesday or Wednesday). If you have to a question, post that question on the course web site under "Forums;" I'll look at those before finalizing Thursday's class. I would encourage you to do this each week.

Self-test problem, week 1 Name: _____

You may spend up to 25 minutes on this problem. Do your work on this sheet in the space provided and turn it in separately. Do not work with others or refer to the textbook, though you may consult the equation sheet posted online. Your score on this problem will not be included in your homework grade; it is solely for feedback to you. (However, you *will* receive credit for one homework problem for completing it.)

A cylindrical optical fiber made of glass with refractive index 1.50 is used to guide the light collected by a medical endoscope. It is inserted into the artery of a patient (with the endoscope on the end). The index of refraction of the surrounding blood is essentially the same as that of water, 1.33. Assume for the purpose of this problem that the fiber axis is perfectly straight.

Light is incident on the flat end of the endoscope from the blood at an angle to the axis of the fiber as shown in the figure. It travels into the glass, and then reflects from the glass-fluid interface to continue traveling along the fiber.



(a) What is the maximum angle θ_{axis} that a light ray going into the fiber can make with the fiber's axis and undergo total internal reflection along the fiber?

(b) To make the angle larger, so that the fiber can collect light from a larger area, would you want to surround the fiber with cladding material with index of refraction larger than 1.33, or smaller than 1.33? Explain the logic of your answer briefly. Your explanation can be purely qualitative or can involve calculations, either is fine as long as it is rigorous!

(If you need more space, continue on the back)