Waves and Fields (PHYS 195): Week 13

Spring 2009 v1.0

Intro:

In this last week of the semester we study physical optics and, in particular, the effects of diffraction and interference. This is cool stuff on its own but it is just the tip of an iceberg: Interference is at the heart of many of the wild effects. On Monday we study the double slit experiment. This has played two key roles in the development of physics. First it helped show that light is a wave. (Geometric optics works so well one might guess that it was a particle - Newton did!) Second, it has illuminated a new property of matter - its quantum-wavey nature.

Reading:

- HRW 35
- HRW 36 especially sections 1-5 and 7

Physics Topics:

- Lenses
- Huygens' principle
- Interference
- Diffraction
- Single and double slit interference patterns

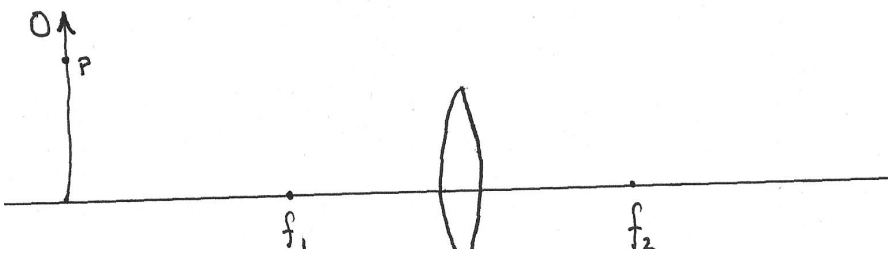
Problems:

(1) Using a carefully constructed ray diagram, show why the image of Eeyore behind both mirrors actually was reversed left to right in the demo.

(2) Explain the "missing light bulb" demo shown in class on Wednesday, April 29. Use ray tracing and the algebraic relation. Was the image real or virtual?

(3) Download the lens Phet application by following the link from the Phys 195 website. Play with the program a bit. Notice that you can move the object and lens.
   (a) Explain the difference between principal rays, "many rays", and "marginal rays".
   (b) Using "many rays", shrink the lens diameter down to 0.3 m, explain what happens to the rays and the image.
   (c) Moving the object inside the focal point, what happens to the image? What would you do to see an image? Click on the virtual image box to see whether, this image appears where you expect it to.
   (d) For $n = 1.63$, $d_o = 40$ cm, what are d_i and M equal to?

(4) A thin convergent lens L has principal foci f_1 and f_2 as shown. The lens forms an image (not shown) of the object O.



(a) Is the image of the whole object or part of the object? Explain your reasoning.
(b) Consider point P. Determine what happens to light emanating from P. Sketch appropriate rays on the diagram.

(5) Galileo describes his first telescope[1] as follows "First I prepared a tube of lead, at the ends of which I fitted two glass lenses, both plane on one side while on the other side one was spherically convex and the other concave." So he used both a diverging and a converging lens.
(a) With the eyepiece placed inside the focal point of the objective, use ray tracing to show that the image is upright. This makes the telescope useful for terrestrial viewing.
(b) With your diagram find the angular magnification of the telescope.
(c) If $f_o = 30$ cm and $f_e = -10$ cm, what was the magnification of this telescope?

(6) HRW 35.13
(7) HRW 35.19
(8) HRW 35.38
(9) HRW 35.70
(10) In the collection at the Guggenheim in New York City there is a piece of sculpture that I find puzzling. It consists of a long tube of aluminum mounted on a wall. The tube has a square cross section about 20 cm across and is about 6 m long. That is it! Although the whole sculpture is utterly unremarkable, if we look *into* the tube we see a startling "rainbow" of color way down the tube (about 4 m away). Soon after manufacture, aluminum acquires a thin layer of aluminum oxide ($n = 1.76$). The first (outside) color you see is violet. How thick is the oxide layer on this sculpture?

Lab:

Interference and Diffraction

A look ahead...

Next week, ... well, 195 will be all over next week, won't it?

[1] A typical Galilean telescope with which Jupiter's moons could be observed was configured as follows. ... The objective lens was stopped down to an aperture of 0.5 to 1 inch and the field of view was about 15 arc-minutes (about 15 inches in 100 yards). ... The glass was full of little bubbles and had a greenish tinge (caused by the iron content of the glass); the shape of the lenses was reasonable good near their centers but poor near the periphery (hence the restricted aperture); the polish was rather poor. The limiting factor of this type of instrument was its small field of view–about 15 arc-minutes–which meant that only a quarter of the full Moon could be accommodated in the field. - From http://es.rice.edu/ES/humsoc/Galileo/Things/telescope.html

When I think of the poor gentlemen of the Senate who believed they were getting an invention they could monopolize for their own profit. . . . Why, when they took their first look through the glass, it was only by merest chance that they didn't see a peddler, seven times enlarged, selling tubes exactly like it at the corner of the street.

–The Curator, from Bertolt Brecht's play *Galileo*