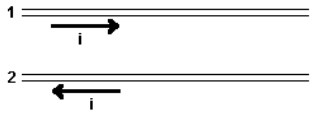
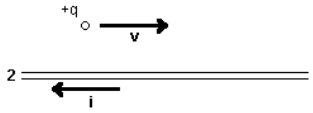
A Tale of Two Wires (25,000 points)

2.) Two wires, marked 1 and 2 as shown below, are each 2.50 m long and are separated by a distance d = 0.130 m. They carry currents i_1 = 4.00 A and i_2 = 2.50 A. (a) Find the forces $\vec{F}_{1on2}$ and $\vec{F}_{2on1}$. Indicate whether the forces are attractive or repulsive.

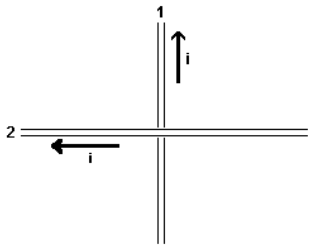


(c) Find the strength of the magnetic field from wire 2, $|\vec{B}_2|$, for $r = d$. Sketch $\vec{B}_2$ on the diagram above.

(d) Suppose that instead of wire 1, there is a small particle 0.130 m above wire 2, with a charge $q = +5.36 \times 10^{-8}$ C, and traveling at 311 m/s. What is the magnitude and direction of the magnetic force, $\vec{F}_B$, acting on the particle?

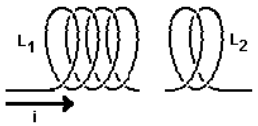


(e) Find the magnetic force on wire 1 due to wire 2, $\vec{F}_{2on1}$, for crossed wires as shown here.



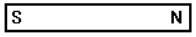
Mutual Self-Admiration Society Meeting (25,000 points)

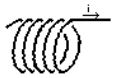
3.) (a) There are two coils $L_2 = \frac{1}{2} L_1$. If these two coils were part of a transformer, and the primary (L_1) voltage was 110 V 60 cycle A.C., and the current in the primary is 31.0 A, find the current in the secondary assuming that there is no power loss in the transformer.



(b) If the power plant is 20 miles away, and the power lines each have a resistance of 187 Ω, find the power lost in the wires if the power lines are at 120 V... versus (c) if the power lines are at 5000 V.

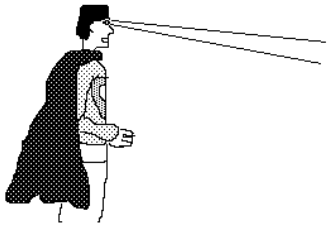
(d) Sketch the magnetic field lines for the bar magnet and the solenoid coil shown below.





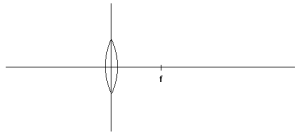
(e) So far, we have been unable to detect magnetic monopoles. But if we ever did, show what the magnetic field lines for an isolated North pole would look like.

The Man of Steel: Defending Truth, Justice and The American Way (25,000 points)



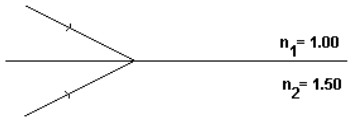
4.) Superman (star of comic books, TV and movies) is supposed to have many special powers, including X-ray vision. X-rays, of course, are both a form of light (electromagnetic radiation) and a dangerous type of radiation. A typical X-ray has a wavelength about the same size as a typical atom: $\lambda = 1.00$ Å $= 1.00 \times 10^{-10}$ m. (a) What is the frequency, *f*, of such an X-ray?

(b) Parallel light rays passing through a positive lens will converge on the focal point. What is the focal length of a flat piece of glass? *Hint: Where do the parallel light rays go (or meet) if they pass through a flat piece of glass?*



(c) Superman, of course, has perfectly normal regular vision. However, when he is disguised as Clark Kent, he wears eyeglasses that he doesn't need. If the glasses have a strength of +1.00 diopters (this corresponds to a focal length, f = +100 cm), what focal length lens would you have to add to cancel the lens in the glasses? What kind of lens is this? *Hint: focal lengths add exactly the same way that series capacitors do.*

Two light rays hit the air-glass in the phone booth at $\theta = 60°$. Make you calculations and show on the diagram what happens to the refracted and reflected rays of (d) the light ray coming from the air and (e) the light ray coming from the glass.



Refractions on Prismatic Reflections (25,000 points)

5.) Here's a glass prism (*n = 1.56, 60° × 60° × 60°*) in air. A light ray comes in from somewhere to the left at point ①. It experiences a total internal reflection at point ② at the critical angle θ_c, and then exits the prism at point ③. Calculate θ_c, then figure out all the other angles. *NOTE: The angles shown in the drawing here are not likely to be correct, so don't just measure them with a protractor! The ray is shown merely to suggest which way it goes. If you find that the ray does not exit at point ③, then merely indicate this – do not take the ray tracing further.*

(a) θ_c =

(b) θ_1 =

(c) θ_2 =

(d) θ_3 =

(e) θ_4 =

(f) θ_5 =