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Physics 2 Recitation Notes March 1

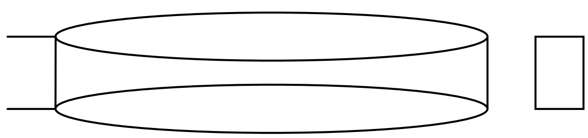
Quiz Answers:

I certainly hope you got these! This was not intended to be a challenge at all, but rather to ensure your mastery of the concepts. Let me give you the answers anyway:

Suppose an electron is flying through space (ignore relativity) as shown:

The direction of the field is into the page.

Suppose I put a coil of wire on the desk as shown:



The bar magnet to the right has its North end up. When I close the circuit, the magnet moves away from the coil; therefore, their respective magnetic moments point in the same direction. Thus, the conventional current is going counterclockwise as viewed from above. A mean student tricked me (which is why you only needed one or the other to get this right): Note that the magnetic dipole moment points from South to North, so outside the magnet, fields point from North to South.

No partial credit was given for these problems, but you only needed one or the other right for full credit.

Problem 17.3:

The electron in figure 17.64 is traveling at $3 \cdot 10^6 \frac{m}{s}$. Ignoring relativity, the electric field is $\frac{q_e}{4\pi\varepsilon_0 r^2}\hat{r} = \frac{q_e}{4\pi\varepsilon_0 \left(5 \cdot 10^{-10}\right)^2}\hat{r}$, where the direction vector points to the right. The magnetic field is $\frac{\mu_0}{4\pi}\frac{q\vec{v} \times \vec{r}}{r^2} = \frac{\mu_0}{4\pi}\frac{q_e\left(\cos\left(60^\circ\right)\hat{x} + \sin\left(60^\circ\right)\hat{y}\right) \times \hat{x}}{\left(5 \cdot 10^{-10}\right)^2} = -\frac{\mu_0}{4\pi}\frac{q_e \sin\left(60^\circ\right)\hat{z}}{\left(5 \cdot 10^{-10}\right)^2}$, so that it points out of the page (since q_e is negative).

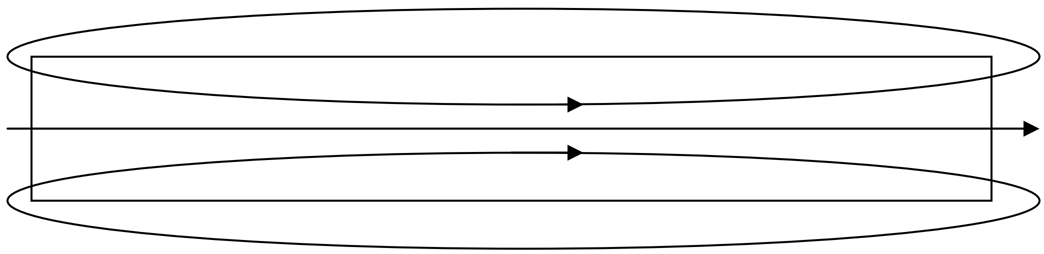
Problem 17:4:

The field from the wire will be $\frac{\mu_0}{4\pi}\frac{2I}{r}\hat{y} = \frac{\mu_0}{4\pi}\frac{2(0.2)}{(0.005)}\hat{y}$, using the formula from page 680. Now calculating the deflection with the Earth's magnetic field $2\cdot 10^{-5}\hat{x}$, I need $\arctan\left(\frac{B_{wire}}{B_{earth}}\right) = \arctan\left(\frac{8\cdot 10^{-6}}{2\cdot 10^{-5}}\right) = 21.8^\circ$, which points up and to the right as drawn in the diagram.

Problem 17.16:

Ignore the instructions in the book, though the spirit of the problem is the same. To analytically do part a requires very advanced math or programming skills. We're going to modify it a little.

First, just draw the magnetic field lines for the ideal solenoid.



Et cetera: the important feature is that you have many, many loops, all passing through the center and looping around the outside.

Now I want to find the magnetic field at a point along the main axis. I take as an assumption that the net current is I, and the number of loops is n. Now I have:

$$\frac{\mu_0}{4\pi}\int_{-\frac{L}{2}}^{\frac{L}{2}}\frac{2\pi R^2 dI}{\left((z-l)^2+R^2\right)^{\frac{3}{2}}} \quad dI = \frac{nI}{L}dl \quad \frac{\mu_0 nIR^2}{2L}\int_{-\frac{L}{2}}^{\frac{L}{2}}\frac{dl}{\left((z-l)^2+R^2\right)^{\frac{3}{2}}}$$

This is a very, very hard integral to do! Even at $z = 0$, even using Taylor expansions, it's still extraordinarily difficult. (Why? Try expanding it about z = 0. This does not eliminate anything but the z in the denominator, and so is still equally difficult to integrate. The z just wasn't a big deal in the first place.) This is one of the major design challenges of a coilgun.

Taking the first-order expansion as you move out from the center of the ring is also far beyond what I could reasonably ask of you.