In **Chapter 5** we (finally) start on magnetic fields.[1] Griffiths begins the chapter with moving electric charges (why not magnets?) and the experimentally derived magnetostatic equations. The chapter then develops the key concepts of the Lorentz force, the Biot-Savart and Ampére laws, the vector potential and boundary conditions.

This material is much richer than the "more linear" electrostatics. Have fun!

Problems of note:

- Just two years ago we celebrated the "birthday" of the electron (really). A schematic diagram of his setup is given in this handout. Before working on part (a.) show that the vertical deflection,y, is
$$y = \frac{qEx^2}{2mv_x^2}$$
between the plates (with no magnetic field). Hence, show that the vertical deflection at the screen is
$$y(L) = \frac{qbE}{mv_x^2}\left(L - \frac{b}{2}\right).$$
Since the beam appears as a single spot rather than an indistinct blob, what must the host of particles have in common? Now proceed onto 5.3 part (a.). Using this, what is the charge to mass ratio of the electron? [Skip part (b).]
- 5.6 Finding current densities
- 5.9 Short and optional - use superposition
- 5.11 Putting the Biot-Savart integration to practice
- 5.13 Amp/'ere's law for a cylinder
- 5.16 (optional) An interesting limit - why does c appear? (something to mull over).
- 5.19 (a) and (b) A result that is good to keep in mind
- 5.25 (a) and find the vector potential for a solenoid. Can the magnetic field be zero in a region where the vector potential is nonvanishing?
- 5.31 On BC's
- 5.36 The magnetic moment of the spherical shell of Example 5.11
- 5.39 (optional and short; you may have done this before) An amazing effect, especially when quantum mechanics is included (see presentations).

Notes on text:

- page 204 The key equation for the motion of charged particles. The examples on the next couple of pages are classic.
- page 214 How did we derive Eq. (5.29) in the first week?
- page 215 Griffiths looses a great opportunity to get his "static/stationary" definitions precise. Let's fix this problem. The physics behind the full mathematical definition is this: A **stationary** system is time independent (when you know the solution at one time, you know it for all time). A **static** system is stationary *and* is invariant under time reversal (t goes to $-t$). With these

[1] If we were working through Maxwell's treatise on electrodynamics he would have us study electrostatics, magnetostatics, and electrodynamics *simultaneously*.

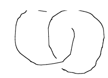
definitions "stationary current" doesn't sound so strange at least to some ears. Can you think of a system which is stationary but not static?

Also on page 215, where did this monster, Eq. (5.32), come from? On the pronunciation on the name, think French. (See presentations)

- page 225 The familiar and important Ampére's law is derived from Biot-Savart. Show that the RHS is equivalent to

$$\mu_o \sum_{j}^{N} I_j .$$

The sum here is over the N current loops which are linked with the integration loop. Does this linking number have a sign? Linking is a property of a collection of closed loops. For example



are linked.
- page 228 Locally, the current sheet used in the solenoid of Example 5.9 is identical to the current sheet of Example 5.8. Why aren't the fields equivalent, i.e. Eq. (5.56) and Eq. (5.57)?
- page 234 The vector potential - a step closer to reality or a step away? (see presentations)
- page 243 Multipoles for **A**
- page 244 The magnetic dipole moment is introduced. Do you buy the argument? Go back and study Eq. (1.108).
- page 246 Would we get the same motion as we did for problem 3.49? (Achtung: Intentionally vague question)

Presentations:

- The Levitron! For this presentation we will learn to use a new toy and investigate its physics. In the presentation you will present Earnshaw's theorem for magnetic fields, demonstrate the toy, and give a full discussion of the physics behind it. See http://www.swarthmore.edu/NatSci/smajor1/Phys112/lev.html and references therein.
- The Biot-Savart law from pronunciation to Amp/'ere. It is also a bit embarrassing that the interaction between two current elements does not obey Newton's Third Law (see 5.49). (or is it?) References: Lyness *Contemp. Phys.* **4** (1963) 453. Peach and Shirely *Am. J. Phys.* **50** (1982) 410. Whitney *Am. J. Phys.* **56** (1988) 871.
- The vector potentials: Do they have physical meaning? Read and discuss with us the article *Am. J. Phys.* **64** (1996) 1361
- (optional) Present 5.39 and the Quantum Hall Effect (what was the discovery, why did it result in a Nobel Prize).
- (optional) Work out 5.56 and tell us more about the "finest achievement of QED."

After you have done some initial work please come by so we can talk about your presentation.