PH631: Electromagnetic Theory
A Note on Prerequisites

A. Stetz, September, 2007

Welcome to the OSU Physics Department. We would like to make your transition from undergraduate physics to graduate courses as smooth as possible. It has been our experience that many students find this transition difficult because their undergraduate physics program did not emphasize the same material that we assume at the beginning of our graduate courses. This web page is intended as a "checklist" for the graduate sequence PH631, 632, 633, Introduction to Electromagnetic Theory. If you find a few items on the list for which you feel unprepared, you might review them before the beginning of the fall quarter. If you find this material completely unfamiliar, we encourage you to start with our senior-level courses in electromagnetism and/or mathematical methods.

Physics

Most beginning graduate students have had an upper division course in electromagnetic theory using texts such as *Foundations of Electromagnetic Theory* by Reitz and Milford, or *Introduction to Electrodynamics* by David Griffiths. The important topics are:

1. Electrostatics: The significance of **E**, **D** and the scalar potential. Dielectric polarization. The notion of energy stored in a field. Laplace's equation and Poisson's equation.
2. Magnetostatics: The significance of **B, H** and the magnetic scalar and vector potentials. Magnetic polarization. Ampere's law. Current and current density.
3. Maxwell's equations: Faraday's law. Displacement current.

We cover all this material "from scratch," but in a rather abstract way. Most students understand everything they have heard twice. This requires that you have already heard it once!

Mathematics

There does not seem to be one standard text in math methods or one customary body of knowledge that we can assume. In general, the math gives students more trouble that the physics. The following list, therefore, is rather detailed and specific.

1. One should be completely comfortable with vector calculus. Not just "div, grad and curl," but also the various integral theorems such as Stokes's law and the divergence theorem.
2. One should also be comfortable with the basic coordinate systems: Cartesian, spherical and cylindrical.

3. It is helpful to have seen the solutions to Laplace's equation in these coordinate systems. Those would be trig functions in Cartesian, spherical harmonics in spherical, and (gasp!) Bessel functions in cylindrical coordinates.
4. One should know how to manipulate the Dirac delta function. Students who put a delta function in the denominator are routinely taken out and tied to a tree. (Note: this remark is for internal use only. I will delete it immediately.)
5. Perhaps the most useful tool in all of mathematical physics is the expansion of a function in terms of a complete set of some standard orthogonal functions. We do this routinely with discrete and continuous Fourier transforms, spherical harmonics, and in other courses, Hermite and Laguerre polynomials.
6. The second most useful tool is the expansion of a function in power series so that one can make approximations. There are several ways of doing this, which come under the headings of Taylor's and MacLaurin's series.
7. Perhaps the third most useful tool is the Green's function. This is not usually covered in undergraduate courses, but a little familiarity will ease the pain of your first encounter.
8. One should know how to use separation of variables to solve the linear partial differential equations that are ubiquitous in mathematical physics.
9. Finally, you should know basic algebra. This would include complex numbers, trig functions, infinite series, and simultaneous linear equations.

We hope you will find this list useful. We try to teach all this material to our undergraduates, and so we tend to assume (usually incorrectly) that "everyone" knows it. We would be glad to recommend other texts and study material for each of these topics. You are welcome to contact me at stetza@ucs.orst.edu or by telephone at 541-737-1698.