Physics 214. Electricity and Magnetism. Professor Michael Dine

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Winter, 2011. Syllabus

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Office hours: Tuesday 1:00-3:00 (subject to change) or by appointment.

Course website: go to department website and click on Dine (or just google dine physics 212). Homework and solutions and handouts will be posted here.

Course Description:
This is the second quarter of the standard electricity and magnetism ("Jackson") course. The material of the second quarter, which principally involves the dynamics of the electromagnetic field, is particularly rich. We will encounter relativity, in a more unified and compelling form than you have perhaps seen up to now, and radiation, scattering, and similar topics.
This will be a challenging course – for you and for me. It is important to devote a lot of time to it. You will need to keep up with the reading. The reading has to be done in a very active way, with pen and lots of scrap paper ready. Similarly for review of class notes. The problem sets are challenging.
Books on Reserve:

1. Landau and Lifschitz, *Classical Theory of Fields.*
2. Panofsky and Philips, *Classical Electricity and Magnetism*
3. Feynman Lectures on Physics, Vol. 2

I will put other books on reserve from time to time as seems appropriate.

Homework, exams,etc: There will be a problem set about once per 1.5 weeks. Whether the mid term and final will be in class or take home will be subject for discussion as the time approaches.

Very **tentative Schedule; will be updated as quarter progresses.**

Chapter numbers refer to Jackson, unless accompanied by LL for Landau and Lifschitz (I will provide handouts for LL)

It is important to do the indicated reading.

1. Week 1: (Jan 4,6) Some review of First Quarter, and a Few Items Not Covered From Chapter Six and Seven

2. Week 2 (Jan. 11,13). Waveguides: of practical importance, but brings in nice mathematics (in the idealized case of perfectly conducting walls) and interesting and intuitively understandable physics, when one considers dissipation in real systems. (Chapter 8)

3. Week 3 (Jan 18, 20) Waveguides (continued).

4. Week 4 (Jan 25,27) Special Relativity: In a sense, it is silly that we wait this long to take up special relativity; LL deal with this from the start. Silly because Maxwell's equations *are* relativistically covariant. Were it not for some foolish late nineteenth century distraction with the ether concept, this symmetry would surely have been noted much earlier. In any case, we will deal with many aspects of this topic: Lorentz transformations of coordinates and momenta, and of the fields and field equations. The latter are most simply understood in terms of the potential four vector, in a suitable class of gauges. We will see that the electric and magnetic fields are naturally grouped as a second-rank antisymmetric tensor under Lorentz transformations, and that described this way, their transformation properties are simple. We will discuss the action principle for particles in electromagnetic fields and for the fields themselves. From this point of view, as stressed by Einstein, the electric and magnetic fields are independent dynamical entities, just as much so as the coordinates and momenta of particles. Maxwell's equations and the Lorentz force law will be seen to follow from very simple considerations – almost entirely from Lorentz invariance and gauge invariance (chapter 11; LL chapters 1-4.).

5. Week 5 (Feb. 1,3). Particles in Electromagnetic Fields (Chapter 12) Week 6 (Feb. 8, 10) Radiation. Here things get really interesting. We will first consider the simplest (and by far most important cases) of electric and magnetic dipole radiation. We can derive all of the results needed here very simply. We will consider applications both to systems like atoms and molecules (semiclassically) and macroscopic antennae. Then we will follow your text in developing a quite general treatment of the multipole expansion. This will introduce to some more intricate (and beautiful) mathematics (a Haber moment). Most of us, in practice, will encounter only the first few moments. (chapter 9 and LL, chapter 9)

6. Week 7 (Feb. 15, 17). Radiation, continued. Scattering and diffraction: we will begin, again, by considering very simple examples, which can be done "on the back of a (large) envelope", deriving, for example, the Thompson formula. We will then follow your text in developing the theory more generally, with applications to interesting macroscopic phenomena such as the blueness of the sky (chapter 10).

7. Week 8 (Feb. 22,24). Scattering and diffraction, continued. Energy loss, Cherenkov radiation. The problem of energy loss of charged particles passing through matter is an important one in almost all branches of physics. For example, the rate of energy loss is a function of a particle's velocity (as opposed to curvature of trajectories in a magnetic field, which depends on momentum). The names of Bohr and Bethe figure prominently in the history of this topic. (chapter 13).

8. Week 9 (Mar. 1,3). Radiation by moving charges: here we will consider in more detail the radiation by particles moving along known trajectories. Again, this is a beautiful topic (yes, really!), despite the fact that it is associated with a notorious Nazi and tormenter of Einstein. It is also of great importance in considering particle accelerators, especially the problem of synchrotron radiation, which we will consider in some detail (Chapter 14, LL Chapter 8).

9. Week 10 (Mar. 8,10). Radiation by moving charges (continued); radiation damping and a taste of the quantum theory if time permits (chapter 16; LL Chapter 9)