Electrodynamics (PHYS 480) Ninth Guide

Fall 2014 v1.0

Chapter 8 is short in pages but full of new concepts and intriguing problems. In it you will find angular momentum of fields, the Maxwell stress tensor, field energy, energy flux density, and a quirk in linear momentum. All of these are central subjects to the study of electrodynamics and, in fact, any field theory as some of you saw in GR last year.

With Chapter 9 we move into applications of electrodynamics, the first being waves. The chapter begins with a rather long review of waves in one dimension (section 9.1). Just skim this section as needed. I will largely skip this, since so much of it is review from 195. Perhaps the most important for us is the use of the complex number notation as the rest of the chapter makes use of this perhaps-somewhat-less-familiar material. In section 9.2 we see the derivation of the wave equation. This derivation is absolutely central to the field. The chapter continues with variations on this theme, i.e. waves in linear media, waves at a boundary, and waves in a tube or "guide." This material of sections 9.3 and 9.4 is new core stuff for this course.

From then on we have some options. We could delve further into wave guides section 9.5) or launch quickly into potentials and radiation. Have a look ahead to see if anything strikes you as a "must do" topic.

We are laying catch-up on the problems so we start with Chapter 7...

BTW we will return to section 7.3.5, Maxwell's in matter...

Problems:

(1) 7.24 Computing self-inductance
(2) 7.28 Field energy three ways
(3) 7.34 Finding B in a charging capacitor
(4) On Thursday November 13 I had to rush to the intriguing end of the example. In so doing I simply stated that the induced electric field at a radius r *between* the two coaxial cylinders was

$$\mathbf{E}(r,t) = \left(\frac{\mu_o \dot{I}}{2\pi}\ln r + C\right)\hat{\mathbf{z}}$$

   (a) Show that this was correct and find what C is.
   (b) Now assume that the battery is replaced by an AC current given by $I(t) = I_o \cos\omega t$, find the induced electric field.
   (c) Find the displacement current density J_d and the total displacement current I_d.
   (d) Find the ratio of I_d and I. If the outer cylinder was 2 cm in radius and the inner one was 0.5 cm, how high would the frequency have to be so that I_d is 1 % of I? Explain why this would show why Faraday never discovered displacement current and why it is often safe to ignore the displacement current, unless the frequency is extremely high.

(5) 7.44 Superconductivity
(6) 7.45 The standard superconductivity demo and an image dipole!
(7) 8.2 This is practice in calculating the energy (density) and Poynting vector for the two "blunt wires" configuration (used in the displacement current discussion of chapter 7). Express your result in part (a) only in terms of the parameters given (makes the later parts easier).
(8) 8.7 Working with the stress tensor in a simple geometry.

Notes on text: These notes are on Chapter 9. See the Eighth guide for the notes on Chapter 8.

- page 382 A curious choice of a definition. In particular, why does Griffiths choose to include a "continuous medium"?

- ** pages 393-8 A key derivation and a style of reasoning we started to use last week and will continue to use. It comes in two parts, derivation of the diff eq'ns and the solutions. Notice how the Maxwell equations are again used to find the final form on page 398. Also, Eq. (9.50) may look trivial but its importance is HUGE. Can you derive it directly from $\nabla \cdot E = 0$ and Eq. 9.49? Try!
- page 398 The concepts of the last chapter applied to e&m waves. Isn't Eq. (9.57) so intuitive? See how Eqns. 9.64, 59, 57, and 55 fit together.
- page 401 Linear media is very nice. Amazing! We can just transcribe the work of the last section. Note how we can derive the index of refraction directly from Maxwell's equations (for linear media!)
- More on next guide ...