Chapter 4: As the final topic on electrostatics, we turn to dielectric materials, i.e. those materials which become polarized when emersed in an electric field. Polarization is both a cause and an effect of electric fields - a property which makes them difficult both conceptually and, occasionally, calculationally (see e.g. problem 4.23). As Griffiths slowly reveals, clarification comes from identifying the chief aim of this study - finding the *macroscopic* fields - and distinguishing free and bound charges.

Griffiths' writing in this chapter is not as crisp as before. Many of the arguments are of a more "hand wavy" nature. In parts of the chapter this means that the reading goes faster, in other sections, we have to read closely.

Problems of note:

- 4.2 Use Gaussian surface to find **E**. (Thanks to Griffiths that the wavefunction is a $l = 0$ solution!) Here's a useful integral

$$\int e^{-az} z^n dn = \frac{e^{az}}{a^{n+1}} \left[(az)^n - n(az)^{n-1} + n(n-1)(az)^{n-2} + \cdots + (-1)^{n-1} n!(az) + (-1)^n n! \right].$$

  When you expand, go to third order.
- 4.6 Again, first find the field using a technique of last chapter then find the torque.
- 4.16 Using superposition for the electric field
- 4.28 Using the "suspect" energy argument
- 4.33 The boundary conditions of Eqns. 4.29 and 4.26 will help.
- 4.38 Was a section in the last edition, now a problem. What is the "else" field?
- 4.40 (optional) A problem which uses electrostatics and statistical mechanics to calculate the polarization of a polar material. If you take a liking for this problem write up a presentation for seminar.

Notes on text:

- page 162-3 Griffiths introduces a tensor to describe polarization. Why? How would you write this as a matrix?
- page 166 - the definition of polarization
- In pages 166 - 168 The concept of a bound charge emerges. This is worth reading with more care than usual.
- page 169 Is there a misprint in Fig 4.10? Shouldn't the field lines be in closed loops?
- page 173 The second paragraph is the **key** point of the notion of fields in matter. This is the notion of the spacetime average of the electric field.
- page 175-6 The electric displacement is introduced - important material.
- page 186 Boundary value problems revisited.
- page 190 Note the use of the image charge method.
- page 192 Nice explanation of the energy
- page 195 A slightly mysterious derivation: How does the uniform, vertical field used in the derivation yield a horizontal force? We will have a more full discussion of this argument in seminar (see Presentations).

Presentations:

- Griffiths introduces a small zoo of new parameters, $\epsilon, \epsilon_r, \chi_e, \alpha, P, \rho_b, \sigma_b$. Put these in a pattern which is easy to understand. (Consider presenting 4.38).
- A more careful derivation of the force on a dielectric (Section 4.4.4): Read the article by Margulies [*Am.J. Phys.* **52** (1984) 515]. Copy the entire article to distribute in seminar and present the solution, including Appendix A.