The agreement of the results seems to show that light and magnetism are affections of the same substance, and that light is an electromagnetic disturbance propagated through the field according to electromagnetic laws.

—James Clerk Maxwell, 1865.

1. Read Chapters 1 and 2 of Boyd.

2. Begin with the most general relationship between $P$ and $E$, as discussed in Lecture 1, and describe all assumptions and approximations needed to arrive at Eq. (1.1.2) of the text. Indicate when these assumptions might fail or if they are fundamental.

3. Suppose that through some experiment you are able to determine that the imaginary part of the linear susceptibility is a very narrowly peaked spike at $\omega_0$ to a good approximation given by the expression

$$\text{Im} \, \chi^{(1)}(\omega) = K \delta(\omega - \omega_0).$$

(a) Find the real part of $\chi^{(1)}$.
(b) Plot both real and imaginary parts either by hand or computer.
(c) What is wrong (unphysical) with $\chi^{(1)}$? Add a term to make $\chi^{(1)}$ right. (hint: The fields must be real.)
(d) Discuss the physical meaning of your result.

4. Suppose a monochromatic field of frequency $\omega$ illuminates a $\chi^{(2)}$ medium.

(a) What frequency components are present to first order in $\chi^{(2)}$?
(b) To second order in $\chi^{(2)}$?
(c) To third order in $\chi^{(2)}$?