Homework 9 (Due. Mar 13)

Griffiths makes several statements and claims in Chapter 9 without really working out all the details. So please show what you feel are the main steps/big ideas in the questions below:

1. The wave equation and boundary conditions

1. Starting with Maxwell's equation in matter (in terms of the $\mathbf{D}$ and $\mathbf{H}$ fields) show that, for a linear homogeneous dielectric ($\mathbf{D} = \varepsilon\mathbf{E}$, $\mathbf{B} = \mu\mathbf{H}$) with no free charges or currents ($\rho_{free} = 0$, $\mathbf{J}_{free} = 0$), both the $\mathbf{E}$ and the $\mathbf{B}$ fields obey a wave equation with a wave speed given by $v = 1/\sqrt{\mu\varepsilon}$.
2. Starting from the same equations as in part 1, rewrite them in integral form, and then briefly sketch out for us the reasoning which leads to all the boundary conditions on $\mathbf{E}$ and $\mathbf{B}$ at a planar interface between two different linear materials (labeled 1 and 2), with permittivities and permeabilities ε_1, μ_1 and ε_2, μ_2, respectively. (Again, assume no free charge or current densities)

2. Reflection and Transmission

In Griffiths' section 9.3.2, (Reflection and transmission at normal incidence) he finds reflection and transmission coefficients (R and T). But he has made the assumption that $\mu_1 = \mu_2 = \mu_0$. Drop that assumption, i.e. keep μ_1 and μ_2 general, and find the general formulas for R and T. To check, explictly confirm that $R + T = 1$, still (as it must be). *Hint: Don't redo work Griffiths has done for you. Use whatever you need from section 9.3.2, just be careful not to use results where he has assumed $\mu_1 = \mu_2 = \mu_0$. I claim you can express your final results for R and T purely as very simple functions of β only!*

3. Perpendicular polarization

In the lecture notes (and/or Griffiths 9.3.3), we worked out the case of reflection and transmission at any angle. But we considered the case where the incident E-field is polarized in the plane of incidence. Go through that section again, but work out the different case where the E-field is polarized perpendicular to the plane of incidence. (You may once again assume $\mu_1 = \mu_2 = \mu_0$.) Specifically, what I mean by "work out" is:

1. Make a clear sketch (modeled on Griffiths figure 9.15) of the geometry and angles for this case. Then, write out what the four boundary conditions become in this case (i.e. modify Griffiths Eq 9.101 through 9.104 appropriately for this new situation).

2. Find the new "Fresnel Equations", i.e. a version of Eq 9.109, but for this polarization case. Explicitly check that your Fresnel equations reduce to the proper results at normal incidence!

3. Replicate Griffiths Figure 9.16, (but of course for this perpendicular polarization case.) **Use a Jupyter notebook** please. Assume $n_2/n_1 = 2.0$ Briefly, discuss what is similar, and what is different, about this case from what Griffiths solved. Is there a "Brewster's angle" for your situation, i.e. a non-trivial angle where reflection becomes zero?

4. Again **in a Jupyter notebook**, replicate Griffiths Figure 9.17 (the one at the end of 9.3) but again, for this perpendicular polarization case, and again assuming $n_2/n_1 = 2.0$ and again using a computer

to plot. Show using your graph that $R + T = 1$ for this situation, no matter what the angle. Briefly, comment on the physics!

Turn in parts 3 and 4 using your GitHub repo.

4. Paired Project Problem - Planning your project

After reviewing the feedback you received on your project idea, work with your partner to consider the plan for the next 5 weeks. In doing this answer the question: How do you intend to structure the work? Explain the details of what will be done and who will be doing what. The expectation is that you have written 2-3 paragraphs describing the work and a detailed timeline. Where applicable you should also describe the roles and responsbilities of each member of the group at different points in the timeline.

Each team will turn in a single repository.