UNIVERSITY OF MISSISSIPPI
Department of Physics and Astronomy
Electromagnetism II (Phys. 402) — Prof. Leo C. Stein — Spring 2019

Problem Set 3

Due: Thursday, Feb. 28, 2019, by 5PM

As with research, feel free to collaborate and get help from each other! But the solutions you hand in must be your own work. All book problem numbers refer to the third edition of Griffiths, unless otherwise noted. I know we don't all have the same edition, so I also briefly describe the topic of the problem.

1. Griffiths problem 8.5a-d (Infinite parallel-plate capacitor's stress tensor, force per unit area, momentum flux, recoil per unit area).

2. Griffiths problem 8.9a-b (Solenoid with a ring outside, energy flux).

3. **Solenoid filled with plasma**. Suppose we have a solenoid of radius a aligned with the $\hat{z}$ axis with n turns per unit length, and the inside of the solenoid has been filled with a low-density plasma. The plasma has a number density n_p and the charge carriers (electrons, say) each have charge q and mass m. All the charge carriers are at rest at time $t = 0$.

   (a) Suppose we turn on the current through the solenoid so that between $t = 0$ and $t = \tau$, the current increases linearly, $I(t) = I_1 \frac{t}{\tau}$. What is the magnetic field $\boldsymbol{B}$ in the solenoid? From Maxwell's equations, what is the electric field $\boldsymbol{E}$? (For this step you can ignore the influence of the plasma).

   (b) Find the energy flux and the momentum density in the electromagnetic field inside the solenoid.

   (c) From the Lorentz force on the charge carriers, solve for the motion of any given charge within the solenoid that starts out at a radius s from the axis of symmetry. (You can imagine it could be quite difficult to self-consistently solve for changing electromagnetic fields and the moving charges, since they all affect each other – which is why we ignored the influence of the plasma in item 3a).

   (d) From the result of item 3a, find the Maxwell stress tensor in the basis of $\hat{z}, \hat{s}, \hat{\phi}$ (i.e. you are looking for components like $T_{\phi\phi}$, T_{zs}, etc.).

4. Griffiths problem 9.2 (Standing waves are superposed traveling waves).

5. Griffiths problem 9.5 (Wave incident on a boundary where two materials meet).

6. Griffiths problem 9.8 (Circularly polarized wave).