Physics 322, Winter Quarter 2016
Electrodynamics: Homework Assignment 6
(a) Turn in all problems and clearly note all constants and assumptions you use. (1-point penalty each otherwise)
(b) Use 8½ x 11 paper & staple (1-point penalty each otherwise)
(c) Due February 18 either 9:00 am in class or 8:45 am in the instructor's mailbox; late homework gets 0.

1. Conduction versus displacement currents. Consider copper threaded by an alternating electric field $E_0 \cos\omega t$, with frequency $\omega/2\pi$ = 1 Hz. You can assume the permittivity of copper is close to ε_0.
a. Find the ratio of the magnitude of the displacement current to the magnitude of the conduction current. Which dominates at typical radio frequencies?
b. Is the conduction current in-phase or out-of-phase with the electric field? If out-of-phase, by how much does the conduction current lead or lag (specify which)?
c. Is the displacement current in-phase or out-of-phase with the electric field? If out-of-phase, by how much does the current lead or lag (specify which)?

2. Magnetic pressure. Consider a long solenoid carrying current *I*, of radius *R*, length *L*, with *n* turns/length. Notice the **B** field at the windings applies a force to the windings. The current is held constant while the magnetic pressure expands the radius of the solenoid by *dR*. according to the principal of virtual work.
a. Find the resulting increase in the magnetic energy.
b. A source supplies the current. Find the extra energy the source needs to supply for the expansion to take place. Hint: Why might the source need to increase its voltage?

c. Explain why your answers in a and b are different.
d. Hence, find the magnetic pressure. That is: suppose you had a difference in parallel **B** across a surface, find the pressure on the surface.

3. A cylinder of length *L* and radius *R* carries a uniform current density **J** in the axial direction. Consider a charged particle beam entering the end of the solenoid in the axial direction. Each beam particle carries charge *q* and has momentum *P*.
a. Relative to the direction of the current, what's the direction of the particle beam so the beam is focused (and not de-focused)?
b. Find the focal length of the cylinder. You can assume the focal length is much longer than the length of the cylinder (the thin lens approximation).

4. A very simple plasma is a material containing charge carriers and having conductivity σ. Suppose the plasma is threaded by a magnetic field **B**(**r**,t), where **r** is some position in the plasma. For simplicity, assume the permittivity and permeability are ε_0 and μ_0. Find $\nabla^2\mathbf{B}$. This is one of many "plasma equations".

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