

Private Reading, Fall 2024

## Assignment 9

*Reading:* Griffiths chapter 8 on “Conservation Laws”. Section 8.2.2 on Maxwell’s Stress Tensor is particularly hairy. I wrote section 4.2 of the *Notes* particularly to explicate this section of Griffiths.

Also *Notes on Electrodynamics* chapter 3, “Conservation of Charge and the Maxwell Equations” and chapter 4, “Energy and Momentum”.

*Problems:* Due Thursday, 7 November.

- Additional problem: *Magnetic energy and electric generators*

All electrical generators work by moving a wire through a magnetic field, or vice versa. Sometimes the magnetic field is produced by permanent magnets (“magneto alternators”), and sometimes it is produced by current driven by the generator itself (“induction generators”). Al Fin has claimed, in “How Much Power do Wind Turbines Use”, 24 August 2010

<http://oilprice.com/Alternative-Energy/Wind-Power/How-Much-Power-Do-Wind-Turbines-Use.html>,

that induction generators are necessarily less efficient than magneto alternators, because “induction generators... bleed power from the grid to create their magnetic fields.”

Critique this claim. In particular, distinguish between energy used to create a magnetic field, to maintain a magnetic field, and to collapse a magnetic field.

- Griffiths 7.37: *A solution to the Maxwell equations*  
Restrict yourself to the case  $t > 0$ .
- Griffiths 7.39: *Experimental detection of magnetic monopoles*
- Griffiths 7.42: *Electrostatics of a circuit*

This one is hard. (Mark Heald graduated from Oberlin College in 1952. He earned his Ph.D. at Yale and then became a professor at Swarthmore College, where he taught me electrodynamics in spring 1976. I kept in contact with him for many years. On 7 July 2020 he emailed that he was ailing and that “I’ve had a wonderful life with many good friends. No regrets. I know I’m well past my ‘sell by’ date at age 91.” The next day I wrote to him that “I learned many things from you, but the most important one is that in solving a problem you should not just reach a mathematical result, but investigate what that result is trying to tell you about nature.” Four days after that he died.)