PHYS 7325 Homework 1

Professor Halverson

Due: October 4

1. Maxwell's other equations. 10 pts.
In class we did some of the derivation related to this problem, but the goal of this problem is to have you do all of it, go beyond what we did in class, and gain some physical intuition for sources. In the presence of a source term the Lagrangian for electrodynamics is

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - J_\mu A^\mu$$

where $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$ is the standard gauge field strength.

a) 4 points. Derive the classical equations of motion. How many component equations are there? How many might you have expected for classical electrodynamics in the presence of a source?

b) 1 points. Write the equations of motion in terms of $\vec{E}$ and $\vec{B}$. In this familiar form, what is the interpretation of J_μ? What equations are "missing" from this set?

c) 4 points. Now consider $\tilde{F}_{\mu\nu} := \frac{1}{2}\epsilon_{\mu\nu\rho\sigma}F^{\rho\sigma}$ and express it in terms of $\vec{E}$ and $\vec{B}$. Compare to *b*), and use this as a hint to derive Maxwell's other equations. *They are not equations of motion.*

d) 1 points. What happens physically if $J_\mu = 0$, and what are the equations called in that case?

2. Gaussian Integrals. 3 pts. These are so important it's worth deriving them. In appendix 2 of section I.2, derive (18), (22), and the expression in between (23) and (24).

3. Feynman Diagrams. 10 pts. These are book problems. Some answers are in the back, and some of the answers in the back get you started on the right track, but you need to go farther. Use your judgement.

a) I.7.1. 5 points. "Work out" means from first principles. Specifically, demonstrate which n-point function it comes from, what the order in λ is, determine the multiplicative prefactor correctly, and end at (24).

b) I.7.2. 1 points. Derive the multiplicative factor from computing the appropriate n-point function directly and use it to determine what the "symmetry factor" must be to match with Zee's Feynman Rules. This language of "symmetry factor" is conventional, but I prefer just to work out the multiplicative prefactor directly. But if you prefer to directly draw diagrams, rather than starting with the path integral or time ordered product, developing a good sense for how to determine the symmetry factor by looking at the diagram is useful.

c) I.7.3. 3 points.

c) I.7.4. 1 points.