154 Homework 2, due 4/19/17

1. The Higgs boson has $m_H c^2 \approx 120 GeV$. Suppose that the H particle is at rest and that it decays into two photons, $H \to \gamma + \gamma$. Find the magnitude of the spatial momentum of the two photons, $|c\vec{p}_1|$ and $|c\vec{p}_2|$.

2. Suppose that the Higgs boson, with $m_H c^2 \approx 120 GeV$, is traveling along the x-axis with $v/c = 4/5$, and then decays $H \to \gamma + \gamma$. Find the momentum magnitude, $|c\vec{p}_1|$ and $|c\vec{p}_2|$ of the two photons if they are also traveling only along the x-axis.

3. Thomson 3.1.

4. Thomson 17.4.

5. Verify that $\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - j^\mu A_\mu$ is invariant under the gauge transformation. This is similar to exercise 17.3 in Thomson, but I'd like you to include the $j^\mu A_\mu$ term and verify that both that and the other term are separately gauge invariant; the gauge invariance of the $j^\mu A_\mu$ term uses the fact that $\partial_\mu j^\mu = 0$.

6. Thomson 17.7.

7. Verify that $\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - j^\mu A_\mu + \frac{1}{2}m_\gamma^2 A_\mu A^\mu$ violates gauge invariance if $m_\gamma \neq 0$. (Moral: gauge invariance forbids a photon mass. Caveat: there is a way to get around this with a bose condensate. This is what happens in the Higgs mechanism, for the Weak forces. And it is what happens in a superconductor for E and M.)