Short HW 4: **Leptonic Electroweak Theory**

Course: Physics 165, *Introduction to Particle Physics* (2018)
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Due by: **Thursday**, February 1

Note that this short assignment is due in class on Thursday. You have only *two days* to do it. This should be quick, I recommend doing it right after class on Tuesday.

1 Rules of the theory

You may find previous homework assignments useful. In this problem you will motivate the rules of the unbroken leptonic electroweak theory for a single generation[1]. Your symmetries are as follows:

1. Spacetime symmetry: translations in spacetime and Lorentz.
2. U(1) hypercharge, gauged.
3. SU(2) weak, gauged.

Your particle content is:

1. Hypercharge gauge boson, B_μ, required by the gauged hypercharge symmetry. It is spin-1 with no other charges.
2. Electroweak gauge boson, W_μ^A, required by the gauged weak symmetry. It is spin-1 with triplet (adjoint) SU(2) weak charge, $A = 1, 2, 3$.
3. A lepton doublet, $L^{a\alpha}$. This is a spin-1/2 fermion that has hypercharge $Y = -1/2$ and is in the doublet (fundamental) representation of SU(2) weak. The two components have special names, $L^1 = \nu_L$ and $L^2 = e_L$.
4. A left-handed positron, $\bar{E}^\alpha$ that has hypercharge $Y = +1$ and carries no SU(2) weak charge. You can think of $\bar{E}$ as the anti-particle to $(\bar{E})^\dagger = e_R$, a right-handed electron.
5. A Higgs doublet, H^a, that has hypercharge $Y = +1/2$ and is in the doublet (fundamental) representation of SU(2) weak. For now we can refer to the components as H^1 and H^2.

Write out all of the allowed three-particle Feynman rules for this theory in terms of B_μ, W_μ^A, $L^{\alpha a}$, $\bar{E}^\alpha$, and H^a.

Extra credit: write out the allowed three-particle Feynman rules in terms of B_μ, $W_\mu^\pm$, W^3, ν_L, e_L, e_R, and $H^{1,2}$.

Extra credit: What combination of quantum numbers (charges) in this theory seems to give the correct electric charge 'in real life?'

[1] The words 'unbroken' and the reference to 'single generation' are hints that we're going to make things more complicated in the near future.