1. First of all, finish your previous reading assignments.

2. Next, another reading assignment: Chapter 20 of *Peskin & Schroeder* about the Glashow–Weinberg–Salam standard model of weak and EM interaction.

   I shall explain much of this material in class, but I want you to read ahead, and I might skip some important details.

3. And now consider what happens when one adds extra Higgses to the GWS theory. Specifically, let us add a real triplet of scalar fields $\varphi_a(x)$ in the $\mathbf{3}^0$ representation of the $SU(2) \times U(1)$ (*i.e.*, isospin $I = 1$, hypercharge $Y = 0$). Suppose these scalars develop non-zero vacuum expectation values $\langle \varphi_a \rangle \neq 0$ but they are 'aligned' with the VEV of the standard Higgs scalars $\langle H_i \rangle$ such that the photon remains massless.

   (a) Show that the triplet Higgs VEVs modify the Z/W mass ratio (*i.e.*, $M_W \neq M_z \times \cos\theta_W$) but the couplings of the $W^\pm$ and Z^0 bosons to the quarks and leptons remain exactly as in the standard model.

   (b) At low energies $E \ll M_W, M_Z$, weak interactions of quarks and leptons are governed by effective four-fermion couplings stemming from exchanges of virtual $W^\pm$ and Z^0 particles. In current-current form $J_\mu J^\mu$,

$$\mathcal{L}_{\text{weak}} \;=\; -\frac{4G_F}{\sqrt{2}} \Big[J_L^+ \cdot J_L^- \;+\; \rho \big(J_{L3} \,-\, \sin^2\theta_W J_{EM} \big)^2 \Big] . \tag{1}$$

   In the standard model $\rho = 1$ (make sure you understand why). Show that adding triplet Higgs VEVs to the theory leads to $\rho > 1$.