1. Show that the total width of the Z-boson is
\[
\Gamma(Z \rightarrow \text{anything}) = \frac{\alpha M_Z}{12 \sin^2 \theta_W \cos^2 \theta_W} \left\{ \frac{21}{2} - 20 \sin^2 \theta_W + \frac{80}{3} \sin^4 \theta_W \right\}.
\]
Evaluate \( \frac{\Gamma(Z \rightarrow \text{anything})}{M_Z} \), using the experimental value of \( \alpha \) and \( \sin^2 \theta_W \). What is the branch ratio \( Br(Z \rightarrow e^+e^-) \)?

2. Calculate
\[
\frac{\Gamma(\Psi \rightarrow \nu \bar{\nu})}{\Gamma(\Psi \rightarrow e^+e^-)}
\]
summed over the three neutrino flavors.

3. Derive the formula for electron muon scattering given in class.