215a Homework exercises 5, Fall 2015, due Nov. 12 (put under my office door, MH5234)

1. We saw in class that $2 \to 2$ scattering has

$$d\sigma_{2\to 2} = \frac{|\mathcal{A}|^2}{4E_1E_2} D_{2-body} \frac{1}{|\vec{v}_1 - \vec{v}_2|}$$

$$D_{2-body(CM)} = \frac{p_f d\Omega_1}{16\pi^2 E_{CM}} \qquad \text{(divide by 2! if identical final states)}$$

where CM refers to the center of momentum frame. The incoming particles have $p_1^\mu = (E_1, p_i\widehat{e})$ and $p_2^\mu = (E_2, -p_i\widehat{e})$. The outgoing particles have $q_1^\mu = (E_1', p_f\widehat{e}')$ and $q_2^\mu = (E_2', -p_f\widehat{e}')$. We are here being general, allowing $p_1^2 = m_1^2$, $p_2^2 = m_2^2$, $q_1^2 = m_1'^2$ and $q_2^2 = m_2'^2$, which could all be different, depending on which two particles come in and which two go out. Of course, $E_{CM} = E_1 + E_2 = E_1' + E_2'$.

Verify that $|\vec{v}_1 - \vec{v}_2|$, which refer to the velocities of the incoming particles, satisfies $|\vec{v}_1 - \vec{v}_2| = p_i E_T / E_1 E_2$, so

$$d\sigma = \frac{|\mathcal{A}|^2 p_f d\Omega_1}{64\pi^2 p_i E_T^2}$$

2. Compute the CM frame differential cross section $d\sigma/d\Omega$ for $N + \bar{N} \to \phi + \phi$ in our toy model of mesons and nucleons at tree level, i.e. leading order in perturbation theory (no loops). Write the answer in terms of E_{CM}, the scattering angle θ, and the nucleon mass m and meson mass μ.

3. Compute the CM frame differential cross section $d\sigma/d\Omega$ for $N + \phi \to N + \phi$ in the same model, in terms of the same variables.