FINAL TAKE HOME EXAM
Due: 18 January 2008

1. Calculate the Feynman Diagram shown in Fig. 1. Neglect the input momenta and also the d quark mass.
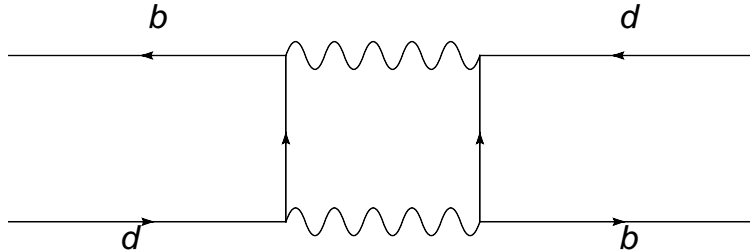

Figure 1: One of the Feynman diagrams describing $B^0 - \bar{B}^0$ mixing

2. Draw the lowest order Feynman Diagrams for the following decays:

   (a) $\Lambda_b \rightarrow \Lambda \ell^+ \ell^-$
   (b) $n \rightarrow p e^- \bar{\nu}_e$
   (c) $\pi^0 \rightarrow \gamma\gamma$

3. In chiral perturbation theory, the pion field can be represented as

$$U = \exp \frac{i}{f_\pi} \begin{pmatrix} \frac{\pi^0}{\sqrt{2}} & \pi^+ \\ \pi^- & -\frac{\pi^0}{\sqrt{2}} \end{pmatrix} \tag{1}$$

where $f_\pi = 132~MeV$. In the lowest order, the Lagrangian can be written as

$$\mathcal{L}_2 = \frac{f^2}{8} \mathrm{Tr} \partial_\mu U \partial^\mu U + \frac{\lambda f^2}{4} \mathrm{Tr} \left(m_q U + m_q^\dagger U^\dagger \right) \tag{2}$$

where m_q is the quark mass matrix.

   (a) What is the mass of the pion?
   (b) Calculate the scattering cross-section for $\pi^+ \pi^- \rightarrow \pi^+ \pi^-$ in lowest order.

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