Homework 4: Due at class on Nov 15

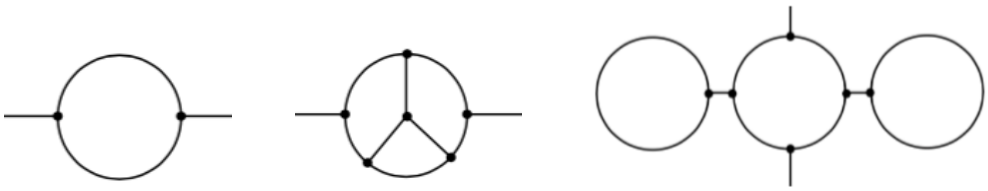
1 Feynman rules in ϕ^3 theory

1.1

Give the Feynman rules for correlation functions to the propagator, the vertex and the external points in position- space and derive from these the Feynman rules in momentum-space for the $\lambda\phi^3$ theory, i.e. $\mathcal{L}_{\text{int}} = -\frac{\lambda}{3!}\phi^3$.

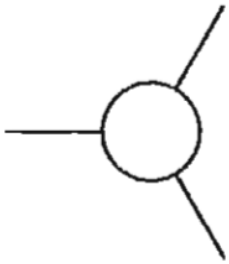
1.2

Calculate the symmetry factors for the following diagrams:



1.3

Now let us consider the one-loop correction to the ϕ^3 term, given by the following diagram. Write down the corresponding amplitude using the Feynman rules in terms of inte-



grals over the intermediate points and Wick contractions, represented with factors of D_F.

2 Bhabha scattering

In this probelm, we consider the process of electron-positron ($e^+e^- \to e^+e^-$) scattering in QED.

2.1

Compute the amplitude for this process by summing two Feynman diagrams. Your answer will depend on the polarizations of the initial and final electrons and positrons. Note that, unlike the $e^+e^- \to \mu^+\mu^-$ process considered in class, your answer will be the sum of two Feynman diagrams. The overall sign is not too important, but make sure to get the relative sign between these two Feynman diagrams correct!

2.2

Imagine that we do not measure the polarizations of the initial or final states. Compute the scattering probability $\frac{1}{4}\sum|\mathcal{M}|^2$, where we average over initial polarizations and sum over final polarizations. Write your answer as a function of the momenta of the incoming and outgoing particles. You may make the approximation where $E_{cm} \gg m$, so that we can just ignore the electron mass.

2.3

Now compute the differential cross section in centre of mass frame, and write it as a function of the Mandelstam variables as

$$\frac{d\sigma}{d\Omega} = \frac{\pi\alpha^2}{s}\left(u^2\left(\frac{1}{s}+\frac{1}{t}\right)^2 + \left(\frac{t}{s}\right)^2 + \left(\frac{s}{t}\right)^2\right)$$

Take the reference frame as in Peskin-Schroeder above Eqn(5.11), write this formula as a function of E_{cm} and θ. Note that the result diverges at $\theta \to 0$. Can you explain why?

3 Peskin & Schroeder Problem 4.3 (linear sigma model)