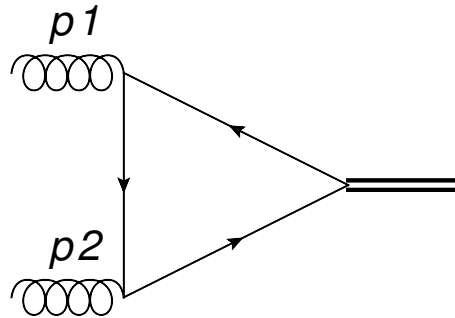


**Exercise 1. Higgs production via gluon-gluon fusion**

The aim of this exercise is to compute the Born-level gluon-gluon fusion Higgs boson production cross section in the Standard Model.

$$g(p_1) + g(p_2) \rightarrow H(p_H).$$

The leading order in perturbation theory is mediated already via a top quark loop.



- Is there only one diagram?
- What kind of interaction relates the top quark and the Higgs boson? Write down all the required Feynman rules.
- What is the most general Lorentz and colour decomposition of the gluon-gluon fusion amplitude? Use Gauge invariance to constrain the terms.
- Calculate the required amplitude using dimensional regularisation. You can proceed as follows:
  - Insert your Feynman rules into your Feynman diagrams.
  - Find a way to project the amplitude to the Lorentz and colour decomposition of the amplitude.
  - Compute all colour and spinor traces.
  - Identify all loop integrals. Try to relate as many integrals as possible to each other to reduce the work you have to do! Can you express everything in terms of only the following three integrals?

$$T(1, 0, 0), T(1, 0, 1) \text{ and } T(1, 1, 1),$$

with

$$T(a, b, c) = \int \frac{d^d k}{(2\pi)^d} \frac{1}{(k^2 - m_t^2)^a ((k + p_1)^2 - m_t^2)^b ((k + p_1 + p_2)^2 - m_t^2)^c}.$$

- Calculate your loop integrals. You can make your life easier by expanding in the dimensional regulator.

- (e) Compute the modulus squared of the amplitude. Sum over out-going and average over incoming particle colours and polarisations.
- (f) Find a way to parametrise the phase-space of the gluon-gluon fusion process.
- (g) Write down the full cross-section for the production of a Higgs boson out of two gluons.
- (h) How would you relate this process to the production of a Higgs boson out of two protons?