This course will introduce the path integral approach to computing scattering amplitudes. The first part of the course will be taught by de Rham and will focus on real scalar fields. Generalization to gauge fields, fermions and leading up to Yang-Mills will be presented in the second part of the course taught by Tolley. We will see how to use perturbation theory and derive the Feynman rules and introduce the concept of renormalization.

Office hours: Tuesdays, 3pm in H506. If you cannot make that time please try dropping by another time, ask me in class or send me an email.

Relevant Textbooks:

Outline

This outline is subject to changes

A. Path Integral

1. Path Integral in QM

2. Path Integral in a Scalar Field Theory
   a) Setup
   b) Discretization
   c) Well-definiteness
   d) Generating Function

3. Free scalar field Propagator
   a) Generating Function
   b) Feynman Propagator

B. Perturbation Theory and Effective Action

1. Feynman Diagrams
   a) Perturbations
   b) Feynman Rules
   c) Popping bubbles

2. One-particle Irreducible Vertices
   a) Connected Diagrams
   b) Irreducible Diagrams
   c) Effective Action

3. Effective Action
   a) Tree-diagrams and classical limit
   b) Effective Potential
4. Cross Section and Decay Rates
   a) Center of Mass and Mandelstam variables
   b) Cross Section
   c) Tree-level Scattering amplitude

C. Renormalization

1. Loop Expansion

2. One-Loop
   a) Loop correction to the Propagator
   b) Regularization
   c) Cut-off Regularization
   d) Pauli-Villars Regularization
   e) Dimensional Regularization

3. Renormalization Group
   a) Renormalization Group Equation
   b) Callan-Symansik equation

4. Effective Field Theory (time permitted)
   a) Low-Energy Effective Field Theory
   b) Naturalness
   c) Fun Stuff