

Carleton University Department of Physics
PHYS 6701 – Quantum Field Theory (Fall 2013)
Course Outline

Instructor: Prof. Heather Logan (logan@physics.carleton.ca, 613-520-2600 x4319, 2450 HP)

Lecture times: Mondays and Wednesdays, 12:30–2:00 p.m., Herzberg 2445

Prerequisites: PHYS 5701 (Intermediate Quantum Mechanics) and PHYS 5702 (Relativistic Quantum Mechanics), or permission of the Physics Department.

Required Textbook: M.E. Peskin and D.V. Schroeder, “An Introduction to Quantum Field Theory” (Westview Press, 1995).

Office hours: To be arranged and announced in class, or contact me via email to make an appointment.

Course Description

The goals of this course are to develop the techniques for calculating beyond tree level and to complete the theoretical basis of Feynman rules by introducing the path integral formalism. Parts of this outline will evolve as the course progresses.

I. Review: interacting fields and Feynman diagrams [Peskin Chapter 4.]

Correlation functions of interacting fields, Wick’s theorem, Feynman diagrams, S-matrix. Feynman rules for scalar ϕ^4 theory, Yukawa theory, and quantum electrodynamics.

II. Radiative corrections: introduction [Peskin Chapter 6.]

Structure of the electron vertex function, interpretation of the formfactors. Techniques for evaluation: Feynman parameters, Wick rotation, Pauli-Villars regularization. Electron $g-2$. Soft bremsstrahlung, infrared divergence and its cancellation, KLN theorem.

III. Radiative corrections: some formal developments [Peskin Chapter 7.]

Field-strength renormalization, LSZ reduction formula. Optical theorem, Ward-Takahashi identity, electric charge renormalization. Dimensional regularization, standard basis for one-loop tensor integrals.

IV. Systematics of renormalization [Peskin Chapter 10.]

Counting of ultraviolet divergences, renormalizability. Counterterms.

V. Functional methods (path integrals) [Peskin Chapter 9.]

Path integrals, functional derivatives and the generating functional, Feynman rules, Faddeev-Popov gauge-fixing and the photon propagator, functional quantization of spinor fields.

VI. Quantization of non-abelian gauge theories [Peskin Chapters 15 and 16.]

Faddeev-Popov ghosts, unphysical degrees of freedom.

VII. Quantization of spontaneously broken gauge theories [Peskin Chapters 20 and 21.]

R_ξ gauges.

Assignments and Grade Distribution

Homework assignments (65%):

Homework will be assigned approximately every two weeks and will consist of problems from the textbook and/or additional problems provided by me. Homework assignments will be distributed in class and/or by email.

Final exam (35%):

There will be a take-home final exam, to be done over a period of 4 or 5 days. Details will be arranged toward the end of term.

Academic Policies

Please read and be familiar with the following Carleton University policies:

Privacy and freedom of information: <http://www6.carleton.ca/privacy/> .

Academic integrity: see item 18 of <http://calendar.carleton.ca/grad/gradregulations/> , in particular the sections on plagiarism and the unauthorized resubmission of work.

Academic Accommodation Policies

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy obligation: write to me (H. Logan) with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: <http://www2.carleton.ca/equity/> .

Religious obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: <http://www2.carleton.ca/equity/> .

Academic accommodations for students with disabilities: The *Paul Menton Centre* for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your *Letter of Accommodation* at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (*if applicable*) at <http://www2.carleton.ca/pmc/new-and-current-students/dates-and-deadlines> .

You can visit the Equity Services website to view the policies and obtain more detailed information on academic accommodation at <http://www2.carleton.ca/equity/> .