Univ. of Manitoba Dept. of Physics & Astronomy
Fall 2022

PHYS 7440 Quantum Field Theory

Lecture Times: TBA, 1.5 hr/week — Room: TBA

Instructor: Dr. Andrew Frey — E-mail: a.frey@uwinnipeg.ca
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WWW: `http://ion.uwinnipeg.ca/~afrey/FW2223/qft/`
Office Hours: by appointment (zoom)

Course Description

This course presents an introduction to fundamental concepts in relativistic quantum field theory using scalar fields. The major topic is developing the theory of the S matrix in perturbation theory, mostly in the path integral formalism of quantum mechanics, including loop corrections and renormalization.
3 credit hours; approximately 18-20 lecture hours; 7 Sept to 23 Dec 2022 (inclusive of examination dates)

Textbooks

- **Required**: *Quantum Field Theory* by Mark Srednicki
- **Supplemental**: David Tong's lecture notes
- **Supplemental**: *Fields* by Warren Siegel (arXiv:hep-th/9912205)
- **Supplemental**: Sidney Coleman's lecture notes

I may also assign some extra reading (from other texts, journal articles, etc) provided online. I have chosen references that are largely available online. However, there are many excellent textbooks on quantum field theory, and I am happy to discuss what other books may be useful and available through your university library.

Topics

We will discuss

- Relativity and Quantization — Relativistic Quantum Mechanics & Lorentz Invariance — Canonical Quantization — Path Integral Quantization
- Correlation Functions and Scattering — LSZ Formula — Feynman Rules — S-matrix — Cross Sections & Decay Rates
- Loops — Loop Diagrams — Renormalization — Effective Action — Resonances & Infrared Physics — Wilsonian Renormalization

Each secondary topic (marked with —) will take about a week, but not all topics above will be covered equally. Also, some topics may be skipped due to time constraints or taught in different orders. If time allows, we may discuss other topics (particularly related to symmetries).

Teaching Outcomes: By the end of the course, students should be able to derive Feynman rules, use them to calculate physical observables (cross sections and decay rates), and renormalize a quantum field theory.

Assignment Policies

Reading: Reading assignments will be posted on the course web page and homework assignment each week. Students are responsible for keeping up with the reading and must submit a list of questions about the reading in advance of the class meeting according to the deadline listed on the homework assignment.

Homework and Presentations: Assignments will be posted on the course web page in PDF format on a weekly basis; they will consist of ungraded practice problems and problems to be marked. During our class meeting before the assignment is due, students will present their work on one or more homework problems and should be prepared to discuss all (practice and marked) problems.

The assignment will then be due at 10:59PM on the listed due date (typically one week later); make sure to mark your solution with your name. See below for submission instructions. Homework solutions will be posted on the course web page as soon as possible after assignments have been collected. Collaboration on the problems is allowed, but each student must write up the solutions independently. Late assignments will **not** be accepted without prior permission from the instructor.

Final Exam: The final exam will be take-home format with scheduled times. You will receive detailed instructions about allowed resources in advance of the scheduled dates. You should prepare your test/exam solution following the Assignment Submission Instructions below using "exam" instead of assignment number and upload it to the given link by the scheduled deadline. Please follow the detailed instructions on the exam.

Assignment Submission Instructions: All assignments should be uploaded as PDF files to the link specified on the course webpage (and assignments). Note that you will not be able to see or edit your submission, so you must resubmit the whole file if you need to make changes. Assignment PDF files may be black-and-white scans (preferred) or photographs of a written hardcopy or prepared with LaTeX or other software. If you do not have access to a scanner, there are apps available for Apple and Android mobile devices; if you need to submit photographs, they *must* be converted to PDF. LaTeX submissions should be in PDF format. Alternately, you may type your assignment with a word processor and *must* use an equation editor for mathematics; you *must* submit your work in PDF format. Please label your files with your first initial, last name, and assignment number (for example, `AFrey_hw1.pdf`); if you need to break your assignment into multiple parts, label them in order with lower case letters (`AFrey_hw1a.pdf`, `AFrey_hw1b.pdf`, etc). You will each receive via email a personalized link to a shared folder where I will return your marked assignments. **Only PDF files will be accepted for all assignments.** You will receive a personalized link for access to your marked assignments during the term. *Please keep this link private since that is personal information.*

Organization: Your homework and exam solutions should be written (or typed) neatly with steps explained *as if you were writing a research paper or lab report.* Not all algebra need be shown if the steps are explained in words; however, showing your work may improve your credit if you make a mistake. Homework that is not neatly organized and written will not be graded and will be given **zero credit** (one warning will be allowed).

Regrading: If you feel that there is a mistake in grading, I will regrade each problem in question completely. It is possible that newly discovered mistakes will reduce your credit. Please also see the section on appeals.