

Carleton University Physics Department
PHYS 5702 - Relativistic Quantum Mechanics (Winter 2022)
Course Outline

Instructor: Prof. Daniel Stolarski (he/him)

Email: stolar@physics.carleton.ca

Lecture Schedule: Wednesday & Friday, 11:35 P.M. - 12:55 P.M., Southam Hall 317.

The COVID-19 situation is rapidly evolving and thus the format of this course is subject to change throughout the semester. The plan as of January 3, 2022 is to have the course be fully online for the first three weeks, Jan 12 - 28, and then to transition to a HyFlex system where there are in person lectures which will be simulcast live via zoom. In both phases, this course will have **synchronous meetings**. This course requires reliable high-speed internet access and a computer (ideally with a webcam), and a headset with a microphone. If there are issues with equipment, please email as soon as possible.

Web conferencing sessions in this course will be recorded and made available only to those within the class. Sessions are recorded to enable access to students with internet connectivity problems, who are based in different time zone, and/or who have conflicting commitments. If students wish not to be recorded, they need to leave the camera and microphone turned off. You will be notified at the start of the session when the recording will start. Please note that recordings are protected by copyright. The recordings are for your own educational use, but you are not permitted to publish to third party sites, such as social media sites and course materials sites. You may be expected to use the video and/or audio and/or chat during web conferencing sessions for participation and collaboration. **If you have concerns about being recorded, please email me.**

Course Calendar Description: Relativistic wave equations. Expansion of S matrix in Feynman perturbation series. Feynman rules. An introduction to quantum electrodynamics with some second quantization. Gauge theories. May include introduction to Standard Model.

Prerequisites: PHYS 5701.

Required Textbook: Michael E. Peskin and Daniel V. Schroeder, “An Introduction to Quantum Field Theory” Reading, USA: Addison-Wesley (1995).

Useful References: There are many great QFT books, these are some of my favourites, but this list is by no means complete.

Matthew D. Schwartz, “Quantum Field Theory and the Standard Model,” Cambridge University Press, 2013.

Anthony Zee, “Quantum Field Theory in a Nutshell,” Princeton University Press, 2010.

Steven L. Weinberg, “The Quantum Theory of Fields: Volume 1, Foundations,” Cambridge University Press 2005.

Course webpage: See Brightspace

Teaching Assistant: Hassan Easa (hassaneasa@cmail.carleton.ca)

Student Hours¹: Hassan will have virtual office hours with the schedule to be determined. Prof. Stolarski's office hours are by email appointment. You can ask either Hassan or Prof. Stolarski questions about the material or assignment problems, but for questions about assignment marking, please contact Hassan.

Assignments and Grading

Homework Assignments: 50%

Assignments will be posted on Brightspace, with the due date and time noted there. Please scan and submit your solutions via Brightspace in a **single pdf file**. Assignments will be given roughly every other week.

Working through problems is an essential part of developing a deep understanding of the material in this course. Students are encouraged to work together to understand the problems; however, the work handed in must be original.

Late assignments will not be accepted without a legitimate reason, such as illness.

Assignment Presentation: 10%

Each student will present to the class their solution to one assignment problem after they have completed the assignment. You will know when your presentations will be, but you may not be told which problem you will be asked to present. You will be marked based on the clarity of your solution as well as on how you answer questions from your peers.

Final Exam: 40%

There will be a take home final exam at the end of the semester. Students will be given 48 hours to complete the exam. It will be open book and open notes, but you may not consult with any other people or use the internet.

¹Formerly called office hours, likely no longer in an office.

Course Outline

Below is a rough outline of the course, but it may change to fit the pace needed.

Class	Text Sections	Topic Description
Jan 12*		Review of Special Relativity
Jan 14*	2.2	Review of classical field theory and quantum mechanics
Jan 19* & 21*	2.3, 2.4	The Klein-Gordon Field
Jan 26* & 28*	4.2, 4.3	Correlation Functions
Feb 2	4.4	Feynman diagrams
Feb 4 & 9	4.5	The S -Matrix
Feb 11	4.6	Computing S Matrix elements
Feb 16		ϕ^4 Theory
Feb 18	3.1	The Lorentz Group
Feb 23 & 25	Winter Break	No classes.
Mar 2	3.2, 3.3	The Dirac Equation
Mar 4	3.5	Quantization of the Dirac Field
Mar 9 & 11	3.4, 3.6	Dirac Matrices and Discrete Symmetries
Mar 16 & 18	4.7, 4.8	Feynman rules for Fermions and QED
Mar 23 & 25	5.1–5.3	$e^+e^- \rightarrow \mu^+\mu^-$
Mar 30 & Apr 1	5.4, 5.5	Other QED processes
Apr 6		Catch up
Apr 8	Final class	Review

* Currently scheduled online.

Inclusive teaching statement:

Science is for everyone. I am committed to fostering an environment for learning that is inclusive for everyone regardless of gender identity, gender expression, sex, sexual orientation, race, ethnicity, ability, age, class, etc. All students in the class, the instructor, and any guests should be treated with respect during all interactions. It is my hope that our class will support diversity of experience, thought, and perspective. I will continually strive to create inclusive learning environments and would therefore appreciate your support and feedback. I welcome emails or in-person communications to let me know your preferred name or pronoun. Please see the Faculty of Science Equity, Diversity, and Inclusion (EDI) statement.

COVID-19 and the Classroom

All members of the Carleton community are required to follow COVID-19 prevention measures and all mandatory public health requirements (e.g. wearing a mask, physical distancing, hand hygiene, respiratory and cough etiquette) and mandatory self-screening prior to coming to campus daily.

If you feel ill or exhibit COVID-19 symptoms while on campus or in class, please leave campus immediately, self-isolate, and complete the mandatory symptom reporting tool. For purposes of contact tracing, attendance will be taken in all classes and labs. Participants can check in using posted QR codes through the cuScreen platform where provided. Students who do not have a smartphone will be required to complete a paper process as indicated on the COVID-19 website.

All members of the Carleton community are required to follow guidelines regarding safe movement and seating on campus (e.g. directional arrows, designated entrances and exits, designated seats that maintain physical distancing). In order to avoid congestion, allow all previous occupants to fully vacate a classroom before entering. No food or drinks are permitted in any classrooms or labs.

For the most recent information about Carleton's COVID-19 response and required measures, please see the University's COVID-19 webpage and review the Frequently Asked Questions (FAQs). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca

Please note that failure to comply with University policies and mandatory public health requirements, and endangering the safety of others are considered misconduct under the Student Rights and Responsibilities Policy. Failure to comply with Carleton's COVID-19 procedures may lead to supplementary action involving Campus Safety and/or Student Affairs.

Note about COVID-19 and Mental Health: The global pandemic has led to extra stress and uncertainty for everyone, and while we may all be experiencing the same storm, this does not mean that we are all in the same boat! If you are struggling, please do not hesitate to reach out. I can direct you to resources that might help. Remember that Carleton also offers an array of mental health and well-being resources, which can be found here.

Grade Definition:

In accordance with the Carleton University Undergraduate Calendar Regulations, the letter grades assigned in this course will have the following percentage equivalents:

A+ = 90-100	A = 85-89	A- = 80-84
B+ = 77-79	B = 73-76	B- = 70-72
C+ = 67-69	C = 63-66	C- = 60-62
D+ = 57-59	D = 53-56	D- = 50-52
F < 50	WDN = Withdrawn from the course	
ABS = Student absent from final exam	DEF = Deferred	

Academic Accommodations, Regulations, Plagiarism, Etc.

Carleton University is committed to providing access to the educational experience in order to promote academic accessibility for all individuals. Academic accommodation refers to educational practices, systems and support mechanisms designed to accommodate diversity and difference. The purpose of accommodation is to enable students to perform the essential requirements of their academic programs. At no time does academic accommodation undermine or compromise the learning objectives that are established by the academic authorities of the University. More information can be found here.

University rules regarding registration, withdrawal, appealing marks, and most anything else you might need to know can be found on the university's website, here.

Academic Accommodations for Students with Disabilities

If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC 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 your instructor as soon as possible to ensure accommodation arrangements are made. For more details, visit the Paul Menton Centre website.

Addressing Human Rights Concerns

The University and all members of the University community share responsibility for ensuring that the University's educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the Department of Equity and Inclusive Communities at equity@carleton.ca.

Religious Obligations

Please contact 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, please review the Student Guide to Academic Accommodation.

Survivors of Sexual Violence

As a community, Carleton University is committed to maintaining a positive learning, working and

living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: <https://carleton.ca/sexual-violence-support/>

Accommodations for Missed Work

Carleton recognizes that these are unprecedented times during the COVID-19 pandemic, and that students may be experiencing greater stress and other life factors that are not in their control. As a result, Carleton has put into place a protocol for students to apply for accommodations using a self-declaration form in the event of missed work. The form can be found at: <https://carleton.ca/registrar/wp-content/uploads/self-declaration.pdf>

For Pregnancy

Please contact 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, please review the Student Guide to Academic Accommodation.

Accommodation for Student Activities

Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact 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, see the Senate Policy on Accommodation for Student Activities.

Academic Integrity

Academic misconduct undermines the values of honesty, trust, respect, fairness, and responsibility that we expect in this class. Carleton University provides supports such as academic integrity workshops to ensure, as far as possible, that all students understand the norms and standards of academic integrity that we expect you to uphold. Your teaching team has a responsibility to ensure that their application of the Academic Integrity Policy upholds the university's collective commitments to fairness, equity, and integrity. (adapted from Carleton University's Academic Integrity Policy, 2021). Examples of actions that do not adhere to Carleton's Academic Integrity Policy include:

- Plagiarism
- Accessing unauthorized sites for assignments or tests
- Unauthorized collaboration on assignment and exams

Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy. The Policy is strictly enforced and is binding on all students. For more information, please see Carleton's academic integrity page.

Course Copyright

Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors and students, are copyright protected and remain the intellectual property of their respective author(s). All course materials, including PowerPoint presentations, outlines, and other

materials, are also protected by copyright and remain the intellectual property of their respective author(s). Students registered in the course may take notes and make copies of course materials for their own educational use only. Students are not permitted to reproduce or distribute lecture notes and course materials publicly for commercial or non-commercial purposes without express written consent from the copyright holder(s).

Assistance for Students

Academic and Career Development Services

Writing Services

Peer Assisted Study Sessions (PASS)

Math Tutorial Centre

Science Student Success Centre

Important Dates:

<https://calendar.carleton.ca/academicyear/>

<https://carleton.ca/registrar/registration/dates-and-deadlines/>