

PHYS 4602/5602 Course Outline

Term: Winter 2024

Calendar Description: Standard Model. Properties of leptons, quarks, hadrons. Fundamental interactions: photon, gluons, W/Z bosons. Higgs boson. Conservation laws, invariance principles, quantum numbers. Decay rates and scattering cross-sections. Quantum electrodynamics and chromodynamics. Resonances. Weak interactions, CKM matrix, parity and CP violation. Neutrino masses and oscillations. Future directions.

Prerequisite(s): [PHYS 4707](#) or permission of the Department.

**General Information**

Class: Tuesday and Thursday 11:35 – 12:55

Instructor: Professor Graham (kevin\_graham@carleton.ca)

Office-Hours: Herzberg room 3322 Tuesday 13:00 – 14:00 or by appointment  
By appointment office-hours will sometimes be virtual (i.e. zoom).

Teaching- Assistant: TBD

**Learning Objectives**

Students will be able to frame problems and solve them in a quantitative way, using such tools as their knowledge and technical experience of physics, mathematics, and other areas.

Students will be introduced to the main concepts of particle physics.

Students will develop an understanding of the underlying foundations and build both conceptual and quantitative ability to understand the physics of elementary particles and their interactions.

**Course Organization**

The course will cover the majority of the material in the course textbook including:

- introduction to particle physics
- relativistic kinematics
- decay rate and scattering cross-section
- Dirac equation
- symmetries
- QED
- QCD
- weak interactions
- electroweak model

- neutrinos
- Higgs boson
- the future (time permitting)

### **Required and Supplementary Texts**

Required: Modern Particle Physics – Mark Thomson  
 associated web pages <https://www.hep.phy.cam.ac.uk/~thomson/>  
 The Review of Particle Physics <https://pdg.lbl.gov/>

Supplementary: Introduction to Elementary Particles – David Griffiths  
 Quarks and Leptons – Francis Halzen and Alan Martin  
 Introduction to High Energy Physics – Donald Perkins  
 Wikipedia (be careful, but not very much is incorrect there)  
 many others...please see me for additional suggestions

Introductory Quantum Mechanics - R Liboff  
 Modern Quantum Mechanics - JJ Sakurai and J Napolitano  
 Introduction to Quantum Mechanics – David Griffiths  
 Quantum Physics - S Gasiorowicz  
 Quantum Physics - L Schiff

### **Course Evaluation**

The final grades will be determined from the better of

- A) 50% assignments  
 20% midterm  
 30% final exam

or

- B) 50% assignments  
 50% final exam

There will be approximately ~6 assignments with approximately ~2 weeks to complete each assignment. In exceptional circumstances, an assignment might be accepted late if sufficient documented reasons are provided. Otherwise, late assignments are not graded. Assignment solutions must be posted as .pdf files to Brightspace, but can be scanned versions of hand-written solutions.

The midterm must be written to successfully pass the course even if the alternate grading scheme provides a better final grade. The midterm is scheduled for February 29<sup>th</sup>.

The final exam must be written to pass the course even if a passing grade is achieved without it.

The grading scheme that provides the highest grade will be used for each student.

The final exam will occur during the final exam period as scheduled by the university.

**Approximate Course Schedule**

Chapters	Tuesday	Thursday
<b>January</b>		
Course Introduction Chapter 1	9 - Course details, introduction to particle physics	11 – introduction to particle physics
Chapter 2	16 – units, special relativity	18 – relativistic kinematics, four vectors
Chapter 3	23 – decay rates and cross-sections	25 - decay rates and cross-sections
Chapter 4	30 – Dirac equation	
<b>February</b>		
Chapter 4		1 – Dirac equation
Chapter 9	6 - Symmetries	8 - Symmetries
Chapter 5 and 6	13 - QED	15 - QED
Winter Break	20 - <i>no classes</i>	22 - <i>no classes</i>
Chapter 7 and 8	27 - DIS	29 - Midterm
<b>March</b>		
Chapter 10	5 - QCD	7 – QCD
Chapter 11, 15, 16	12 – weak interactions	14 – weak interactions
Chapter 12	19 – electroweak model	21 – electroweak model
Chapter 13 and 14	26 – neutrinos	28 – CP violation
<b>April</b>		
Chapter 17	2 – Higgs mechanism	4 – Higgs mechanism
	9 – future/recap	

## Approximate Assignment Schedule

Assignment	Available	Due Date
#1	January 12	January 26
#2	January 26	February 9
#3	February 9	February 27
Winter Break		
<b>Midterm Exam February 29</b>		
#4	March 1	March 15
#5	March 15	March 29
#6	March 29	April 10

## Land Acknowledgement

Here at Carleton University, it is important that we acknowledge that the land on which we gather is the traditional and unceded territory of the Algonquin nation.

## Special Information Regarding COVID-19

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are [a number of actions you can take](#) to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette.

**Feeling sick?** Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton's [symptom reporting protocols](#).

**Masks:** Carleton has paused the [COVID-19 Mask Policy](#), but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change.

**Vaccines:** While proof of vaccination is no longer required as of May 1 to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible, and submit their booster dose information in [cuScreen](#) as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton's COVID-19 response and health and safety requirements please see

the [University's COVID-19 website](#) and review the [Frequently Asked Questions \(FAQs\)](#). If you have additional questions after reviewing, please contact [covidinfo@carleton.ca](mailto:covidinfo@carleton.ca).

### **Note About COVID-19 & Mental Health**

The global pandemic has led to extra stress and uncertainty for everyone, and while we may all be experiencing some of the same challenges, this does not mean that we are all in the same situation. If you are struggling, please do not hesitate to reach out. I am happy to listen, and/or direct you to resources that might help. If you are finding the material in this course difficult or are encountering other challenges, the most important step you can take is to arrange to meet with me. Also remember that Carleton offers an array of mental health and well-being resources, which can be found [here](#).

### **University Policies**

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	B+ = 77-79	C+ = 67-69	D+ = 57-59
A = 85-89	B = 73-76	C = 63-66	D = 53-56
A- = 80-84	B- = 70-72	C- = 60-62	D- = 50-52
F = <50			

WDN = Withdrawn from the course

ABS = Student absent from final exam

DEF = Deferred

FND = (Failed, no Deferred) = student could not pass even with 100% on final exam

### **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 at:

<https://students.carleton.ca/course-outline/>

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:

<https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/>

### **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](mailto: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](mailto:equity@carleton.ca).

### **Religious Obligations**

Please contact me with 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 \(PDF, 2.1 MB\)](#).

### **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 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> [Note that these forms should be used for short-term concerns related to missed work; if you are experiencing chronic, ongoing challenges which necessitate a broader solution, I recommend reaching out to the Paul Menton Centre and/or the Care Support team.](#)

### **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 \(PDF, 2.1 MB\)](#).

### **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 \(PDF, 25KB\)](#).

### **Academic Integrity**

Academic Integrity is upholding the values of honesty, trust, respect, fairness, responsibility, and courage that are fundamental to the educational experience. 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

Please review the checklist [linked here](#) to ensure you understand your responsibilities as a student with respect to academic integrity and this course.

### **Sanctions for Not Abiding by Carleton's Academic Integrity Policy**

A student who has not upheld their responsibilities under Carleton's Academic Integrity Policy may be subject to one of several sanctions. A list of standard sanctions in science can be found [here](#).

Additional details about this process can be found on [the Faculty of Science Academic Integrity website](#). 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.

### **Student Rights & Responsibilities**

Students are expected to act responsibly and engage respectfully with other students and members of the Carleton and the broader community. See the [7 Rights and Responsibilities](#)

[Policy](#) for details regarding the expectations of non-academic behaviour of students. Those who participate with another student in the commission of an infraction of this Policy will also be held liable for their actions.

### Student Concerns

If a concern arises regarding this course, **your first point of contact is me**: Email or drop in during student hours and I will do my best to address your concern. If I am unable to address your concern, the next points of contact are (in this order):



**Note:** You can also bring your concerns to [Ombuds services](#).

### Assistance for Students

Academic and Career Development Services: <http://carleton.ca/sacds/>

Writing Services: <http://www.carleton.ca/csas/writing-services/>

Peer Assisted Study Sessions (PASS): <https://carleton.ca/csas/group-support/pass/>

Math Tutorial Centre: <https://carleton.ca/math/math-tutorial-centre/>

Science Student Success Centre: <https://sssc.carleton.ca/>