

Physics 3718: Advanced Particle Physics
Spring 2022
Syllabus

Location 106 Allen Hall

Time TH, 1:00-2:15 PM

Instructor Brian Batell

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Course Website We will use the Pitt Canvas site for this course:

<https://canvas.pitt.edu>

Log in with your University ID and password and navigate to the PHYS 3718 page. Here you will find announcements, lecture notes, homework assignments and solutions, grades, the syllabus, and other important materials. Please check this site regularly for course announcements.

Text *Phenomenology of Particle Physics*, André Rubbia, ISBN: 978-1-009-02343-9. The publisher page is linked [here](#).

Supplementary Texts There are a variety of excellent textbooks covering particle physics and related topics. A few are listed below:

Particle Physics Textbooks:

Modern Particle Physics, 1st Edition, by M. Thomson

Elementary Particle Physics: An Intuitive Introduction, by A. J. Larkoski

Introduction to Elementary Particles, 2nd Edition, by D. J. Griffiths

Quarks and Leptons: An Introductory Course in Modern Particle Physics, by F. Halzen and A. D. Martin

Collider Physics, by V. D. Barger and R. J. N. Phillips

Quantum Field Theory Textbooks:

An Introduction To Quantum Field Theory, by M. E. Peskin, D. V. Schroeder

Quantum Field Theory and the Standard Model, by M. D. Schwartz

A First Book of Quantum Field Theory, A Lahiri and P. B. Pal

The Quantum Theory of Fields, Vols 1-3, S. Weinberg

Office Hours I will hold regular office hours each week on Tuesdays and Thursdays from 2:15 - 3:30pm (immediately following our class) in 401 Allen Hall (my office).

I strongly encourage you to take advantage of office hours. If my regular office hours do not work with your schedule for any reason, please email me to set up an appointment to meet outside of these times.

Course Description This is the second part of a self-contained two-semester graduate level course covering the theoretical concepts and experimental methods of particle physics. The necessary background in quantum mechanics, special relativity, and quantum field theory--the theoretical frameworks underlying the study of elementary particles -- will be provided. Particle reactions will be studied and calculated using quantum mechanical methods, symmetry principles, and relativistic kinematics. The methods of particle acceleration and detection will be examined. These basic concepts and techniques will be applied to understand a broad range of phenomena in particle physics, building towards an understanding of the Standard Model--our current theoretical description of the elementary particles and their interactions--and its experimental tests.

Selected Topics:

Below is a tentative selection of topics that will be covered in PHYS 3718:

Radiative Corrections in QED
Survey of hadrons and their properties
Electron-proton scattering, deeply inelastic scattering, and partons
Non-Abelian gauge fields
Quantum Chromodynamics (QCD)
Radiative corrections in QCD
QCD at high energies
Approximate chiral flavor symmetries and anomalies
Charm and bottom quarks and quarkonia
The weak interaction at low energies and the Fermi theory
Parity violation in the weak interaction
Spontaneous symmetry breaking and the Higgs mechanism
The electroweak theory
Fermion masses, flavor, and CP violation
Properties of the top quark, the W and Z bosons, the Higgs boson
Neutrino oscillations and neutrino masses
The Standard Model
Basic concepts and methods of particle acceleration and detection
Open questions and physics beyond the Standard Model

Learning Objectives Develop an understanding of the theoretical principles and experimental techniques underlying the study of elementary particle physics. Apply these basic concepts and methodologies to describe and understand a variety of particle physics phenomena.

Homework Homework will be assigned every 1-2 weeks and will be due the following week. Homework will be graded and solutions to the homework will be made available after all students have turned in the assignment. Late assignments will be accepted if turned in no later

than one week after the original due date and will be awarded 50% of the total credit. If there are outstanding circumstances that prevent you from completing the assignment on time, please see me to discuss the matter. I strongly encourage you to discuss the homework problems with your classmates. However, each student must write their own solutions to the homework problems.

Exams There will be one take-home midterm exam and one take-home final comprehensive exam during the semester.

Grading The final grade will be awarded according to the weighted credit for homework (30%), midterm exam (35%), and final exam (35%).

Academic Integrity Students in this course will be expected to comply with the [University of Pittsburgh's Policy on Academic Integrity](#). Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy. Furthermore, no student may bring any unauthorized materials to an exam, including dictionaries and programmable calculators.

To learn more about Academic Integrity, visit the [Academic Integrity Guide](#) for an overview of the topic. For hands-on practice, complete the [Understanding and Avoiding Plagiarism tutorial](#).

Disability Services If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and [Disability Resources and Services](#) (DRS), 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412) 228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Equity, Diversity, and Inclusion The University of Pittsburgh does not tolerate any form of discrimination, harassment, or retaliation based on disability, race, color, religion, national origin, ancestry, genetic information, marital status, familial status, sex, age, sexual orientation, veteran status or gender identity or other factors as stated in the University's Title IX policy. The University is committed to taking prompt action to end a hostile environment that interferes with the University's mission. For more information about policies, procedures, and practices, visit the [Civil Rights & Title IX Compliance web page](#).

I ask that everyone in the class strive to help ensure that other members of this class can learn in a supportive and respectful environment. If there are instances of the aforementioned issues, please contact the Title IX Coordinator, by calling 412-648-7860, or e-mailing titleixcoordinator@pitt.edu. Reports can also be [filed online](#). You may also choose to report this to a faculty/staff member; they are required to communicate this to the University's Office of Diversity and Inclusion. If you wish to maintain complete confidentiality, you may also contact the University Counseling Center (412-648-7930).

Gender Inclusive Language Statement Language is gender-inclusive and non-sexist when we use words that affirm and respect how people describe, express, and experience their gender. Gender-inclusive/non-sexist language acknowledges people of all genders (for example, first year student versus freshman, chair versus chairman, humankind versus mankind, everyone versus ladies and gentlemen, etc.). It also affirms non-binary gender identifications, and recognizes both gender identity and expression. Identities including trans, intersex, and genderqueer reflect personal descriptions, expressions, and experiences. Just as sexist language excludes women's experiences, gendered language excludes the experiences of individuals whose identities may not fit the gender binary, and/or who may not identify with the sex they were assigned at birth. Students, faculty, and staff have the right to control their own identity and to be referred to by the name and pronouns with which they identify. People also have the right to maintain their privacy regarding information they do not wish to share about their identities, including gender identity and pronouns.

Source: [School of Social Work](#)

Health and Safety Statement During this pandemic, it is extremely important that you abide by the [public health regulations](#), the University of Pittsburgh's [health standards and guidelines](#), and [Pitt's Health Rules](#). These rules have been developed to protect the health and safety of all of us. The University's requirements for face coverings will at a minimum be consistent with [CDC guidance](#) and masks are required indoors (campus buildings and shuttles) on campuses in which COVID-19 Community Levels are High. This means that when COVID-19 Community Levels are High, you must wear a face covering that properly covers your nose and mouth when you are in the classroom. If you do not comply, you will be asked to leave class. It is your responsibility to have the required face covering when entering a university building or classroom. Masks are optional indoors for campuses in which county levels are Medium or Low. Be aware of your [Community Level](#) as it changes each Thursday. [Read answers to frequently asked questions regarding face coverings](#). For the most up-to-date information and guidance, please visit the [Power of Pitt site](#) and check your Pitt email for updates before each class.

If you are required to isolate or quarantine, become sick, or are unable to come to class, contact me as soon as possible to discuss arrangements.

Religious Observances The observance of religious holidays (activities observed by a religious group of which a student is a member) and cultural practices are an important reflection of diversity. As your instructor, I am committed to providing equivalent educational opportunities to students of all belief systems. At the beginning of the semester, you should review the course requirements to identify foreseeable conflicts with assignments, exams, or other required attendance. If at all possible, please contact me (your course coordinator/s) within the first two weeks of the first class meeting to allow time for us to discuss and make fair and reasonable adjustments to the schedule and/or tasks.

Sexual Misconduct, Required Reporting, and Title IX The University is committed to combating sexual misconduct. As a result, you should know that University faculty and staff members are required to report any instances of sexual misconduct, including harassment and sexual violence, to the University's Title IX office. What this means is that as your professor, I

am required to report any incidents of sexual misconduct that are directly reported to me, or of which I am somehow made aware. After a report is made, you will be contacted by the Title IX Office for opportunities for support and options for proceeding.

For additional information, please visit the [full syllabus statement](#) on the Office of Diversity, Equity, and Inclusion webpage.

Your Well-being Matters College/Graduate school can be an exciting and challenging time for students. Taking time to maintain your well-being and seek appropriate support can help you achieve your goals and lead a fulfilling life. It can be helpful to remember that we all benefit from assistance and guidance at times, and there are many resources available to support your well-being while you are at Pitt. You are encouraged to visit [Thrive@Pitt](#) to learn more about well-being and the many campus resources available to help you thrive.

If you or anyone you know experiences overwhelming academic stress, persistent difficult feelings and/or challenging life events, you are strongly encouraged to seek support. In addition to reaching out to friends and loved ones, consider connecting with a faculty member you trust for assistance connecting to helpful resources.

The [University Counseling Center](#) is also here for you. You can call 412-648-7930 at any time to connect with a clinician. If you or someone you know is feeling suicidal, please call the University Counseling Center at any time at 412-648-7930. You can also contact Resolve Crisis Network at 888-796-8226. If the situation is life threatening, call Pitt Police at 412-624-2121 or dial 911.

If you have any concerns about the course, please do not hesitate to contact the instructor.