University of Victoria
Department of Physics and Astronomy

Physics 424 - Introduction to Particle Physics

Spring 2026 Syllabus

We acknowledge and respect the Lək̓ʷəŋən (Songhees and Xʷsepsəm/Esquimalt) Peoples on whose territory the university stands, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.

Course Information

Course: PHYS424 - Introduction to Particle Physics
Sections: Lecture A01
Unit Value: 1.5 Units
Lecture Schedule: Tuesday, Wednesday, Friday from 1:30-2:20pm
Prerequisites: PHYS423 or permission of the department

Instructor Information

Instructor: Travis Martin (Pronouns: He/Him, Preferred Address: Travis)
Office Hours: TBD
Email: `travismartin@uvic.ca`
Students are expected to include "PHYS424" in the Subject line of their email, and include their name and student ID in the body of the email. Please allow up to 48h to respond to emails. If you do not receive a response within 48h, it is possible that your email was missed.
Contact Availability: Will respond within 2 business days
In-Term Feedback: Student comments may be sent via email or on Brightspace, however it is not possible for all feedback to be considered within the term.

Teaching & Assessment Modality

This course consists of synchronous, in-person lectures.

Equipment requirements: Students are expected to have a computer with access to the internet, and the ability to program/code in either Python or Matlab.

Learning & Teaching Technologies

Course Webpage: Brightspace `https://bright.uvic.ca/d2l/home/432653` (UVic approved)

Other Technologies: None

Permissible Digital Tools: Students may use Large Language Models (LLM) (e.g.: ChatGPT) to assist in the development of solutions to computational problems only. Students are responsible for ensuring that their solutions are correct. Students must provide screenshots of all relevant

interactions with the LLM as part of demonstrating their worked solution. Students may not use any LLM AI or other AI other than as above for any part of the course.

Exam Policy: Calculators should not be needed for any exam in this course. Cellphones, tablets, and computers are not permitted in in-person exams. Connected personal electronics including smart watches, headphones, smart glasses, or any similar devices are not permitted. Students whose academic accommodations include the use of specialized technologies will be overseen by the CAL Assessment Program.

Course Structure and Description This course will be taught using a traditional lecture style, with strong encouragement of in-class questions and discussion.

Class will not be recorded. Students are encouraged to follow the course notes and textbook to make up for missed material in the case of absence.

Class Materials:

Textbook

A textbook is strongly recommended for this course. The textbook for this course is *Introduction to Particle Physics* by Griffiths (approx $110). The course will regularly reference and use information from the Particle Data Group's *The Review of Particle Physics* which can be found at `https://pdg.lbl.gov/index.html`.

Course Overview

Below is an approximate outline of the order and dates in which material will be covered. Depending on the depth of in-class discussion, the material may take more or less time than anticipated. In the scenario that material takes longer than expected, some material in the course notes may be skipped in the lectures. Students may be tested on any of the material in the course notes, including material that are skipped.

Note: I prefer to structure a course by developing all the base skills and knowledge before application. Chapters 1, 3 and 4 cover the fundamental ideas that underpin Particle Physics. Chapters 2, and 6+ are introductions to how these ideas are applied to understanding what happens to particles.

1. Historical Discoveries in Particle Physics (Ch 1) (Week 1 & 2)
    (a) Equipment for detecting particles
    (b) Particles as waves, the photon as a particle
    (c) Mesons
    (d) Anti-matter
    (e) Neutrinos
    (f) Strangeness
    (g) Quark model
    (h) Quantum Numbers and the Standard Model
2. Relativistic Kinematics (Ch 3) (Week 3 & 4)
    (a) Einstein summation notation & Lorentz Transformations
    (b) Momentum and Energy 4-Vectors
    (c) Conservation of Momentum and Energy
    (d) Collisions
3. Symmetries and Quantum Numbers (Ch 4) (Week 5 & 6)
    (a) Noether's Theorem and Conservation Laws
    (b) Angular Momentum and Spin
    (c) Flavour Quantum Numbers
    (d) Discrete Symmetries
    (e) Charge and Parity
    (f) CP Violation
4. Feynman Diagrams and Feynman Calculus (Ch 2 & 6) (Week 7 & 8)
    (a) Vertices and Feynman Diagrams
    (b) Decays

(c) Scattering

(d) Lifetime

(e) Collisions

MIDTERM

5. Quantum Electrodynamics & Weak Interactions (Ch 7, 8, 9) (Week 9, 10, & 11)
   (a) Dirac Equation
   (b) Feynman Rules for QED
   (c) Casimir's Trick
   (d) Massive Mediators
   (e) Z-boson
   (f) W-boson
6. Beyond the Standard Model (Week 12 & 13)
   (a) Renormalization
   (b) Grand Unification
   (c) Gauge Theories
7. Computational Simulations of Particle Interactions (Not in text, if there is time)
   (a) Monte Carlo Integration
   (b) Monte Carlo Simulation
   (c) Phase Space Generators
   (d) Simulation

FINAL EXAM

Course Outcomes

Summary: Students in this course will survey the field of particle physics, including major experiments, equipment used, and methods of communicating and calculating particle physics results.

Essential Course Components:

- Students must complete the final exam and achieve a minimum 40% grade on the final exam to be eligible to pass this course.

Students who complete these components of the course but who have an overall average less than 50% will receive a letter grade of F. Students who do not write the final exam will receive a letter grade of N, regardless of their overall average in the course.

Intended Learning Outcomes: By the end of this course, successful students should be able to...

- analyze descriptions of experimental results in terms of the Standard Model.
- predict outcomes of relativistic collisions.
- describe behaviour of matter in terms of the fundamental symmetries.
- read and create Feynman diagrams to communicate interactions of particles.
- predict outcomes of particle collision experiments involving the electromagnetic force.
- analyze particle collision experiments in terms of the weak nuclear force.
- perform self-directed literature search on particle physics topics.
- develop a presentation to summarize important details found in a literature search.

Assessments

If the application of this scheme would result in grades that are judged by the instructor to be inconsistent with the University's grading descriptions (`https://www.uvic.ca/calendar/undergrad/index.php#/policy/S1AAgoGuV`), then the instructor will assign percentages consistent with them.

Assignments: 30%

Some assignments may have computational elements, requiring numerical approaches. You may use any programming language you like. Your code is expected to be submitted as part of your assignment.

Group Work Policy: You are allowed to work together with other students on assignments, so long as your work and your solutions are your own.

Neatness Policy: You are expected to treat your assignments with respect. Assignments that are disorganized or difficult to read will receive reduced marks at the marker's discretion.

Project: 25%

There are two options for the project for this course. One option is to write a research paper on a topic of particle physics that is not covered in detail in this course. The other option is to do a computational project, where you will write a code that simulates particle events (Monte Carlo). The project will have multiple due dates with intermediate steps required for submission in order to keep you on track.

Midterm Exams: 15%

There will be one midterm in this course. The midterm may include any material covered in class up to the midterm. The midterm will not be held during class time, but will be provided to students in the morning and will have an 8 hour duration.

Final Exam: 30%

The final exam will be comprehensive in that it will require knowledge of all of the material of the course. The final exam will be a take-home exam that will be scheduled within the final exam period.

Academic Integrity

Students are expected to adhere to the academic integrity policy of the University of Victoria. Details on this policy can be found here: `https://www.uvic.ca/calendar/undergrad/index.php#/policy/Sk_0xsM_V`.

Course Materials:

This course uses the Introduction to Elementary Particles textbook by David Griffiths. Any edition is acceptable, as assignments are not taken from the textbook.

Resources for Students

UVic Learn Anywhere - https://onlineacademiccommunity.uvic.ca/LearnAnywhere/
Many high schools do not adequately prepare students for how to succeed in university, in large part due to the large differences in expected workload. The UVic Learn Anywhere site can help students use their time more effectively and have better outcomes.

UVic Centre for Academic Communication - https://www.uvic.ca/learningandteaching/cac/
Struggling with homework that involves writing? English not your first language? The Centre for Academic Communication has supports available to help you.

UVic Math and Stats Centre - https://www.uvic.ca/science/math-statistics/current-students/undergraduate/msac/index.php
Struggle with math? No matter the course, the Math and Stats Centre can provide assistance. As long as the assistance is with the mathematics of the problem, there are people available to help.

Academic Accommodations - https://www.uvic.ca/students/academics/academic-concessions-accomm
index.php
Have a disability that might be affecting your studies? The Centre for Accessible Learning can review your diagnosis and provide you with academic accommodations that help reduce the effects of the barriers to education you are experiencing as a result of interactions between course design and your disability.

Student Code of Conduct - https://www.uvic.ca/services/studentlife/student-conduct/index.php
Students are expected to behave with respect towards their environment and their community. When there are allegations of student misconduct, this is governed by the Office of Student Life.

Sexualized Violence - https://www.uvic.ca/sexualizedviolence/
If you have been the victim of sexualized violence, this link will help you know how to take the next steps for resolution.

UVic Policies & Statements

General Information for all Students - https://www.uvic.ca/calendar/archives/202301/undergrad/index.php#/content/62daf5e98b7d47001d0fc38b
This is a list of links to information that may be useful to you.

Academic Concession Policy - https://www.uvic.ca/calendar/undergrad/index.php#/policy/HJjAxiGO4
This policy governs your rights and responsibilities in the case that you experience an unexpected and unavoidable circumstance (e.g. illness, injury, bereavement, etc), or have conflicting responsibilities (e.g. varsity sports event).

Policy on Respectful and Productive Environment - https://www.uvic.ca/calendar/archives/202301/undergrad/index.php#/policy/HkQ0pzdAN
This is a statement and policy about UVic's dedication to a respectful and productive learning environment. This includes human rights, equity and fairness, as well as discrimination and harassment policies.

Policy on Religious Observances - https://www.uvic.ca/calendar/archives/202301/undergrad/index.php#/policy/r1q0gofdN
This policy governs students' rights towards religious observances and how to manage your observances with your course responsibilities.

Policy on Non-Academic Misconduct - https://www.uvic.ca/services/studentlife/student-conduct/non-academic-misconduct/index.php
This policy governs students' rights and responsibilities with regard to non-academic behaviour. Students are expected to treat each other and staff/faculty with respect.

Statement on Equity, Diversity and Inclusion - https://www.uvic.ca/vpacademic/about-contacts/equity-diversity-inclusion/index.php
This is UVic's official statement on equity, diversity, inclusion and anti-racism.