

## COURSE OUTLINE

### PHYS435: Introduction to the Physics of Particle Accelerators

**Lectures: 10-11:20, Tuesday and Friday**



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

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#### COURSE DESCRIPTION

An introduction to particle accelerators. The course will start with a survey of different accelerator concepts and some important concepts of electromagnetism and special relativity. The main topics are beam optics and RF systems for acceleration. The course is of interest for students interested in entering the field of particle accelerators and students mainly interested in particle or medical physics who would like to learn the fundamentals of accelerator science. Throughout the course, I will use CERN's Large Hadron Collider (LHC) and other real life accelerators as an example in problems and worked exercises.

#### PREREQUISITES & COREQUISITES

PHYS215 - Introductory Quantum Physics (1.5)

PHYS326 - Electricity and Magnetism (1.5)

#### CONTACT INFORMATION

Instructor: Tobias Junginger

Email: [junginger@uvic.ca](mailto:junginger@uvic.ca)

Office: Elliot 205

Office Hours: Friday 11:30

#### COURSE MATERIALS

Required textbook: Wille – The physics of particle accelerators

All other materials will be provided via Brightspace, including book chapters, slides, and lecture notes. The textbook 'The Science and Technology of Particle Accelerators' by Rob Appleby et al. is available as a free ebook through the UVic library.

## LEARNING OUTCOMES

Upon successful completion of this course, students will be able to:

- Explain different accelerator concepts and their applications.
- Solve simple linear beam dynamics problems using Hill's equation.
- Calculate beam steering and focusing for normal and superconducting dipole and quadrupole magnets.
- Evaluate radiofrequency fields and figures of merit for cavities and waveguides.

## EVALUATION

- 10% for quizzes based on readings. This assessment is mainly to test if reading was done thoroughly
- 20% Individual Presentation
- 30% Homework
- 40% Final exam (oral)

### Note:

**There will be pre-reading before some of the lectures and associated quizzes.**

## COURSE POLICIES

### Late/Missed Assignments or Exams

Exemptions and accommodations can be made upon reasonable request.

### Academic Integrity

UVic's Policy on Academic Integrity is found at [uvic.ca/calendar/future/undergrad/index.php#/home](https://uvic.ca/calendar/future/undergrad/index.php#/home). It is every student's responsibility to be aware of this policy, including policies on cheating, plagiarism, unauthorized use of an editor, multiple submission, and aiding others to cheat. If you have any questions or doubts, please talk to me. For more information, see [uvic.ca/learningandteaching/cac](https://uvic.ca/learningandteaching/cac).

### Use of AI

Please be advised that in this course you are not authorized to use any form of generative AI. In order to successfully complete course activities, generative AI is not required nor welcomed. Students should not make any use of generative AI tools such as ChatGPT, Grammarly, among others that use AI for content generation and editing. As the University of Victoria states on its Academic Integrity Policy "Academic integrity requires commitment to the values of honesty, trust, fairness, respect, and responsibility." Therefore, I expect you to comply with the course syllabus and I encourage you to enhance your academic experience in this course by refraining from use of generative AI.

Exception — Individual Presentation:

For your individual presentation, you may use AI solely for literature search or preliminary exploration of a topic. This exception exists because AI can occasionally help locate relevant sources. However:

- AI-generated slides are strictly prohibited.
- You are expected to design and build your own presentation materials. Presenting slides you did not create yourself typically results in weaker understanding and poorer delivery.

### COURSE CALENDAR AND OUTLINE

UVic Important Dates: [uvic.ca/calendar/dates/](https://uvic.ca/calendar/dates/)

Last day to add courses: January 21th

Last day to drop a course without penalty of failure: February 28th

Final Exam Period: April 7<sup>th</sup>-April 22th

Week	Lecture Dates	Lecture Material (Approximate)
1	Jan 6th and 9th	Logistics, Special Relativity, MeV Units, Applications of Particle Accelerators
2	Jan 13th and 16th	Electrostatic Accelerators, Radiofrequency Linear Accelerators
3	Jan 20th and 23rd	Cyclic Accelerators, Transverse Beam Dynamics – Equations of Motion
4	Jan 27th and 30th	Transverse Beam Dynamics – Beam Steering Magnets
5	Feb 3rd and 6th	Transverse Beam Dynamics – Particle Trajectories, Transfer Matrices, Dispersion, Momentum compaction and slip factor
6	Feb 10th and 13th	Transverse Beam Dynamics – Multiple Particle Dynamics, Courant-Snyder Formulism
7	Feb 17th and 20th	Reading Break – No class
8	Feb 24th and 27th	Transverse Beam Dynamics Beam Matching, Betatron Phase Advance, Tune, Coupled Resonances, Tune Diagram, Field Errors
9	Mar 3rd and 6th	Student Presentations
10	Mar 10th and 13th	RF Systems – Waveguides and Cavities
11	Mar 17th and 20th	Longitudinal Beam Dynamics
12	Mar 24th and 27th	Tutorial – Beam Matching using Trace3D and Guest Lecture: Oliver Kester – TRIUMF Accelerators

### CHANGES DUE TO UNFORESEEN CIRCUMSTANCES

The above schedule, policies, procedures, and assignments in this course are subject to change in the event of extenuating circumstances. In the event of significant changes, a revised outline will be posted/circulated.

### UVIC GRADING SYSTEM – UNDERGRADUATE

As per the [Academic Calendar](#):



Grade	Grade Point Value	Grade Scale	Description
A+	9	90 – 100%	<b>Exceptional, outstanding and excellent</b> performance. Normally achieved by a minority of students. These grades indicate a student who is self-initiating, exceeds expectation and has an insightful grasp of the subject matter.
A	8	85 – 89%	
A-	7	80 – 84%	
B+	6	77 – 79%	<b>Very good, good and solid</b> performance. Normally achieved by the largest number of students. These grades indicate a good grasp of the subject matter or excellent grasp in one area balanced with satisfactory grasp in the other area.
B	5	73 – 76%	
B-	4	70 – 72%	
C+	3	65 – 69%	<b>Satisfactory, or minimally satisfactory.</b> These grades indicate a satisfactory performance and knowledge of the subject matter.
C	2	60 – 64%	
D	1	50 – 59%	<b>Marginal</b> Performance. A student receiving this grade demonstrated a superficial grasp of the subject matter.
F	0	0 – 49%	<b>Unsatisfactory</b> performance. Wrote final examination and completed course requirements; no supplemental.
N	0	0 – 49%	Did not write examination or complete course requirements by the end of term or session; no supplemental.

#### UVIC GRADING SYSTEM – GRADUATE

As per the [Academic Calendar](#):

Grade	Grade Point Value	Percentage*	Description	Achievement of Assignment Objectives
A+	9	90 – 100	Exceptional Work	Technically flawless and original work demonstrating insight, understanding and independent application or extension of course expectations; often publishable.
A	8	85 – 89	Outstanding Work	Demonstrates a very high level of integration of material demonstrating insight, understanding and independent application or extension of course expectations.
A-	7	80 – 84	Excellent Work	Represents a high level of integration, comprehensiveness and complexity, as well as mastery of relevant techniques/concepts.



Grade	Grade Point Value	Percentage*	Description	Achievement of Assignment Objectives
B+	6	77 – 79	Very Good Work	Represents a satisfactory level of integration, comprehensiveness, and complexity; demonstrates a sound level of analysis with no major weaknesses.
B	5	73 – 76	Acceptable work that fulfills the expectations of the course	Represents a satisfactory level of integration of key concepts/procedures. However, comprehensiveness or technical skills may be lacking.
B-	4	70 – 72	Unacceptable work revealing some deficiencies in knowledge, understanding or techniques	Represents an unacceptable level of integration, comprehensiveness and complexity. Mastery of some relevant techniques or concepts lacking. Every grade of 4.0 (B-) or lower in a course taken for credit in the Faculty of Graduate Studies must be reviewed by the supervisory committee of the student and a recommendation made to the Dean of Graduate Studies. Such students will not be allowed to register in the next session until approved to do so by the Dean.
C+	3	65 – 69		
C	2	60 – 64		
D	1	50 – 59		

## COURSE FEEDBACK

I value your feedback on this course. Towards the end of term, as in all other courses at UVic, you will have the opportunity to complete an anonymous **Course Evaluation Survey (CES)** regarding your learning experience. The survey is important for providing feedback to me regarding the course and my teaching, as well as to help the department improve the overall program for students in the future. The survey is accessed online and can be done on your laptop, tablet, or mobile device. I will remind you and provide you with more detailed information nearer the time, but please be thinking about this important activity during the course.

## APPENDICES

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### DEPARTMENT OF PHYSICS AND ASTRONOMY INFORMATION

- Department Website: [uvic.ca/science/physics/index.php](http://uvic.ca/science/physics/index.php)
  - Department General Office: [physgen@uvic.ca](mailto:physgen@uvic.ca)
  - Department Undergraduate Advisor: [phast\\_advising@uvic.ca](mailto:phast_advising@uvic.ca)
  - Department Graduate Advisor: [pkovtun@uvic.ca](mailto:pkovtun@uvic.ca)
  - Department Graduate Program Assistant: [physgrad@uvic.ca](mailto:physgrad@uvic.ca)
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### UNIVERSITY STATEMENTS & POLICIES

- Academic Calendar: [Information for All Students](#)
  - [Creating a respectful, inclusive, and productive learning environment](#)
  - [Accommodation of Religious Observance](#)
  - [Accommodation and Access for Students with Disabilities](#)
  - [Student Conduct](#)
  - [Non-academic Student Misconduct](#)
  - [Accessibility](#)
  - [Diversity / EDI](#)
  - [Equity Statement](#)
  - [Sexualized Violence Prevention and Response](#)
  - [Discrimination and Harassment Policy](#)
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## STUDENT RESOURCES

### POSITIVITY AND SAFETY

The University of Victoria is committed to promoting, providing, and protecting a positive and safe learning and working environment for all its members.

[Student Groups & Resources](#)

### ACADEMIC RESOURCES

UVic Library - *UVic Library offers many services and resources for undergraduate and graduate students.*

[uvic.ca/students/academics/library-services](http://uvic.ca/students/academics/library-services)

Learning Resources - *UVic Learn Anywhere is the primary learning resource for students that offers many learning workshops and resources to help students with academics and learning strategies.*

[onlineacademiccommunity.uvic.ca/uviclearn/](https://onlineacademiccommunity.uvic.ca/uviclearn/)

Centre for Academic Communication - *Offers online and in-person one-on-one tutorials, workshops, and more.*

[uvic.ca/learningandteaching/cac](https://uvic.ca/learningandteaching/cac)

Physics Aid Service – *Addresses problems with conceptual understanding, difficulties encountered with homework assignments, preparation for mid-term and final exams, and occasionally even preparation for external exams such as the MCAT. Instruction may be one-to-one or in small groups, with emphasis placed on engaged interaction between the students and the instructor.*

<https://www.uvic.ca/science/physics/current/undergraduate/pas/index.php>

## **MENTAL HEALTH & WELLNESS**

A note to remind you to take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, getting enough sleep, and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone.

Student Wellness Centre - *Our team of practitioners offers a variety of services to support students' mental, physical, and spiritual health.*

[uvic.ca/student-wellness](https://uvic.ca/student-wellness)

Counselling Services - *Counselling Services can help you make the most of your university experience. They offer free professional, confidential, inclusive support to currently registered UVic students.*

[uvic.ca/student-wellness](https://uvic.ca/student-wellness)

Health Services - *University Health Services (UHS) provides a full-service primary health clinic for students and coordinates healthy student and campus initiatives.*

[uvic.ca/student-wellness](https://uvic.ca/student-wellness)

## **ACCESSIBILITY**

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a documented disability or health consideration that may require accommodations, please feel free to approach me and/or the Centre for Accessible Learning (CAL) as soon as possible.

Centre for Accessible Learning - *The CAL staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.*

[uvic.ca/accessible-learning](https://uvic.ca/accessible-learning)

## ADVISING

For academic advising-related questions, students in the Department of Physics & Astronomy are also encouraged to meet with the Undergraduate Advisor ([phast\\_advising@uvic.ca](mailto:phast_advising@uvic.ca)) as well as an academic advisor in the Academic Advising Centre early in their studies to help map out a plan to declare a major and complete university program requirements.

Academic Advising Centre - *Academic advice and support is currently available by phone, email and virtual or in-person appointments.* [uvic.ca/services/advising](https://uvic.ca/services/advising)

Ombudsperson - *The ombuds office is an independent, impartial, and confidential resource for undergraduate and graduate students and other members of the University of Victoria community. The ombudsperson helps resolve student problems or disputes fairly.* [uvicombudsperson.ca](https://uvicombudsperson.ca)

## ACADEMIC CONCESSION

You can request an academic concession if your course requirements are affected by unexpected and unavoidable circumstances, or conflicting responsibilities. Concession requests can be for an in-course extension, deferral, withdrawal under extenuating circumstances, or an aegrotat. Please speak to an advisor at the Academic Advising Centre if you have questions on how requesting a concession will affect your academic program.

Undergraduate Academic Concessions - [uvic.ca/students/academics/academic-concessions-accommodations](https://uvic.ca/students/academics/academic-concessions-accommodations)

## EQUITY AND HUMAN RIGHTS AT UVIC

EQHR is a resource for students, staff, and faculty who have experienced sexualized violence, discrimination, and/or harassment and are looking for informal and/or formal resolution options as well as advice, coaching, and/or education. We are available for confidential consultations so that you can ask questions and learn your options.

EQHR – By email at [eqhr01@uvic.ca](mailto:eqhr01@uvic.ca) or in-person (Sedgewick C115). [uvic.ca/equity](https://uvic.ca/equity)

Sexualized Violence Resource Office – *If you have been directly or indirectly impacted by sexualized violence, reach out to the SVRO for information, advice, and resolution options (restorative and disciplinary) as well as support options and referrals. The SVRO is both survivor-centred and trauma-informed in their approach. You can reach us by phone at 250-721-8021 or by email at [eqhr01@uvic.ca](mailto:eqhr01@uvic.ca) to book either an in-person (Sedgewick C119) or online appointment.* [uvic.ca/sexualizedviolence](https://uvic.ca/sexualizedviolence)

## RESOURCES FOR INTERNATIONAL STUDENTS

International Centre for Students - *The primary office supporting international students on campus at the university-wide level.* [uvic.ca/international-experiences](https://uvic.ca/international-experiences)

UVic Global Community Initiative - *Provides various supportive programming, including a Mentorship Program and Conversation Partner Program.* [uvic.ca/international-experiences/get-involved/uvic-global-community](https://uvic.ca/international-experiences/get-involved/uvic-global-community)





## **RESOURCES FOR INDIGENOUS STUDENTS**

Indigenous Student Support - UVic offers holistic services to Indigenous students throughout their academic journey. [uvic.ca/students/info-for/indigenous-students](https://uvic.ca/students/info-for/indigenous-students)

Elders in Residence - The Office of Indigenous Academic and Community Engagement (IACE) has the privilege of assembling a group of Elders from local communities to guide students, staff, faculty, and administration in Indigenous ways of knowing and being. [uvic.ca/iace/](https://uvic.ca/iace/)