UVic PHYS 522 & UBC PHYS 560-201
Physics and Engineering of Particle Accelerators
in 2026

Overview:
A 3 credit points course, open to domestic and international students, offered by the UVic and UBC Physics Departments in partnership with TRIUMF.

Dates, times, location:
Course duration: January 8 to April 9, 2026 – mid-term break Feb. 16-20, 2026
Course times: Tuesdays and Thursdays 14:00-15:30 PST

Brief summary of the synopsis:
The course will provide an introduction to the physics, technology and some engineering aspects of particle accelerators with focus on proton and ion accelerator technology.
The course will include a survey of existing accelerator types in particular those which are used at TRIUMF and will also provide an introduction to transverse and longitudinal beam optics.
The course will include an introduction to the physics and technology of ion sources, will give an overview of secondary particle production with focus on radioactive ion beams, of accelerator radio-frequency principles and more detailed aspects of room temperature and superconducting linear accelerators, as well as high energy circular machines.
The course should appeal to students of Accelerator Physics and Physics Engineering, as well as to students of Experimental Nuclear and Particle Physics and other students interested in Particle Accelerators.

Pre-requisites:
Classical Mechanics, Classical Electro-dynamics

Lecturers:
The course will be given by a team of lecturers made up of experts from the TRIUMF Accelerator Division and UVic. Each lecturer is responsible for about 3-5 lectures.

Final Grade:
Weekly homework (due one week after assignment) – 50% (based on completion and quality)
Mid-term exam (February 25, 2026) – 20%
Final Exam (April 21 or 23 (tbd), 2026) – 30%

Course Coordinator:
Oliver Kester, TRIUMF okester@triumf.ca

Course outline and lecture synopsis:

Lecture	Date	Lecturer
1	**January 8**	**Oliver Kester** okester@triumf.ca
Title: Historical overview Linear and Circular accelerators Pre-reading: Wille – chapter 1		
Synopsis: Introduction of the basic principles of acceleration and a review of the historical development of accelerators, both linear and circular.		
2	**January 13**	**Thomas Planche** tplanche@triumf.ca
Title: Cyclotrons – from Classical to Isochronous Pre-reading: Livingood – Principle of Cyclic Particle Accelerators (Chapter 7-8)		
Synopsis: The magnetic resonance is the basis of the Cyclotron. An overview of cyclotron principles, technical solutions and applications will be shown. The specific technologies and parameters of the TRIUMF 520 MeV cyclotron will be explained as an example.		
3	**January 15**	**Thomas Planche** tplanche@triumf.ca
Title: Introduction to particle optics		
Synopsis: Beam optics is the foundation of all charged-particle beam devices and accelerators. In this lecture, we will introduce the concept of phase space, and study transverse beam confinement using focusing elements.		
4	**January 20**	**Thomas Planche** tplanche@triumf.ca
Title: Transverse beam dynamics		
Synopsis: Coordinate system (Frenet-Serret coordinate systems) and the concept of beam emittance and phase space is addressed in this lecture. Examples of particle distribution and their beam emittance, as well as the description of the beam emittance via Courant Snyder ellipse concept will be explained.		
5	**January 22**	**Thomas Planche** tplanche@triumf.ca
Title: Longitudinal beam dynamics Pre-reading: Wangler – chapter 6		
Synopsis: The Equation of motion for particles in the longitudinal direction will be derived. The longitudinal phase space including the separatrix will be introduced. The principle of phase focusing and transit time factor (TTF) will be addressed.		
6	**January 27**	**Thomas Planche** tplanche@triumf.ca
Title: Beam line elements - Magnets (Design and function) Pre-reading: Neil Marks, CONVENTIONAL MAGNETS – I, CERN Accelerator Schools (CAS)		
Synopsis: Magnetic elements are key for particle accelerators and beam line systems. The beam physics sets the requirements for the design of such elements. The electromagnetic principles for dipoles and multipoles of normal and superconducting magnets will be explained.		
7	**January 29**	**Thomas Planche** tplanche@triumf.ca **Christopher Charles** ccharles@triumf.ca
Title: Tour and demos		
Synopsis:		

We will provide a tour to the ISAC-I accelerator and the TRIUMF Offline Ion Source (OLIS) and will provide some demonstration of beam line elements, plasma generation and beam tuning.		
8	**February 3**	**Christopher Charles** ccharles@triumf.ca
Title: Introduction to electron and ion sources Pre-reading: Ian G. Brown – chapter 1 and 3		
Synopsis: The basics of electron emission processes and ionization will be explained. This will include thermionic emission, photo emission and electron impact ionization. Some examples for electron and ion sources will be presented.		
9	**February 5**	**Christopher Charles** ccharles@triumf.ca
Title: Plasma physics and magnetic confinement Pre-reading: I.G. Brown – chapter 2		
Synopsis: Electron and ion beam formation will be introduced. Plasma physics and magnetic plasma confinement are key for the operation of plasma ion sources. Fundamentals from plasma physics and the principle of magnetic confinement of plasma will be addressed. The extraction of ions from a plasma will be discussed in more details.		
10	**February 10**	**Christopher Charles** ccharles@triumf.ca
Title: Plasma ion sources for positive and negative ions		
Synopsis: Due to the different types of plasma generation (discharge, RF, laser) and different strategies of magnetic plasma confinement, there are many different types of plasma ion sources available. The most important plasma ion sources as well as sources for negative ions will be presented.		
11	**February 12**	**Christopher Charles** ccharles@triumf.ca
Title: EBIS and ECRIS - sources for highly charged ions Pre-reading: I.G. Brown – chapter 11 and B. Wolf – chapter 2.11		
Synopsis: The principle of highly charged ion generation in electron cyclotron resonance ion sources (ECRIS) and electron beam ion sources (EBIS) will be topic of this lecture. Basics of these ion sources will be discussed, and examples will be presented.		
Mid term break		
12	**February 26**	**Oliver Kester** okester@triumf.ca
Title: Accelerator based secondary particle production Pre-reading: Krane – chapter 3		
Synopsis: The introduction to methods for producing short-lived radioisotopes beams, in-flight separation and via Isotope Separation Online (ISOL) techniques is foreseen as well as techniques for ion beam purification and selection. An overview of accelerator driven secondary particle production with the example of TRIUMF is given.		
13	**March 3**	**Christopher Charles** ccharles@triumf.ca
Title: Target and ion sources		
Synopsis: An overview of target materials and target technology for the production of radioisotopes for science, medicine and industry will be given. Chemically selective and high-efficiency ion sources for secondary ion beams are reviewed.		

14	**March 5**	**Oliver Kester** okester@triumf.ca
Title: Vacuum physics and technology Pre-reading: D. M. Hoffman – Handbook of Vacuum Science and Technology		
Synopsis: All accelerators and beam line systems that accelerate and transport beams of charged particles need evacuated beam tubes and sophisticated vacuum systems to generate low pressure inside the beam tube. The physics of pressure measurements, of gas pumping will be discussed. Modern vacuum components and systems will be introduced.		
15	**March 10**	**Oliver Kester** okester@triumf.ca
Title: Beam Instrumentation Pre-reading: P. Forck - Lecture Notes on Beam Instrumentation and Diagnostics		
Synopsis: Beam instrumentation and diagnostics is the observation of particle beams with the precision required to tune, operate, and improve the accelerators and their associated transfer lines. The lecture will introduce basic principles of beam diagnostics, destructive or non-destructive for the beam and examples of such beam.		
16	**March 12**	**Robert Laxdal** lax@triumf.ca
Title: Waveguides and cavities Pre-reading: Thomas P. Wangler – RF-Linear Accelerators		
Synopsis: The key infrastructure elements supporting RF-acceleration are wave guides and RF-resonators or cavities. The fundamentals of wave guides, cavities and standing electromagnetic waves in such devices will be discussed.		
17	**March 17**	**Robert Laxdal** lax@triumf.ca
Title: Fundamental parameters of RF resonators (Q-value, shunt impedance, skin depth, surface resistance)		
Synopsis: The physics of RF-resonators and the fundamental parameters of normal and superconducting cavities will be reviewed in this lecture.		
18	**March 19**	**Robert Laxdal** lax@triumf.ca
Title: RF acceleration in periodic structures – Linear Accelerators		
Synopsis: RF-acceleration in linear accelerators (linacs) is introduced as well as basic parameters are discussed. Different types of linacs are introduced as examples to demonstrate the principles.		
19	**March 24**	**Robert Laxdal** lax@triumf.ca
Title: Hadron accelerators: Radio Frequency Quadrupoles (RFQ), IH-structures, DTLs, SRF cavities		
Synopsis: A review of hadron linear accelerators including RFQs, IH-structures, Alvarez and coaxial cavities and the major operational variants of these structures: pulsed vs CW operation and normal conducting vs SRF technologies.		
20	**March 26**	**Robert Laxdal** lax@triumf.ca
Title: Basics of Superconducting RF		
Synopsis: The basic properties and design criteria of superconducting cavities are discussed with emphasis on the technical motivation for the use of superconducting cavities, the surface properties and critical field of superconductors as well as material choices.		

21	**March 31**	**Oliver Kester** okester@triumf.ca
Title: Synchrotrons and Storage Rings Pre-reading: Bryant - The Principle of Circular Accelerators and Storage Rings		
Synopsis: The concept of storage rings, synchrotrons and colliders will be explained. The principle of periodic focusing structures will be shown, with focus on the FODO lattice. Examples of storage rings and colliders will be discussed, in particular the Large Hadron Collider (LHC). The concept of luminosity and beam cooling mechanisms will be addressed.		
22	**April 2**	**Oliver Kester** okester@triumf.ca
Title: Numerical simulation of charge particles in electromagnetic fields		
Synopsis: Basics of numerical simulations of electric and magnetic fields and electromagnetic fields in cavities are presented. In addition, basics of numerical integration of the trajectories of charge particles in electromagnetic fields are explained. The conceptual treatment of space charge using a self-consistent iterative approach will be addressed.		
23	**April 7**	**Robert Laxdal** lax@triumf.ca **Oliver Kester** okester@triumf.ca
Title: Modern concepts of ultra-high gradient acceleration		
Synopsis: Present concepts and the future of SRF, Laser Plasma Acceleration and Wake field accelerators will be presented.		