UBC PHYS 560-201, UVic PHYS 522
Physics and Engineering of Particle Accelerators
In 2019

Overview:
A 3 credit course offered by UBC, UVic Physics Departments in partnership with TRIUMF.

Dates, times, location:
Course duration: Jan. 10 to April 4, 2019 – mid-term break Feb. 18-22
Course times: Tuesdays and Thursdays 14:00-15:30 PST
Course location: TRIUMF (Main Office Building conference room)
Lecture video System: We will use “blackboard collaborate” for digital learning
https://ca.bbcollab.com/collab/ui/scheduler/login
It will allow for video recording, sharing lecture power point files and chats with students.

Brief summary of the synopsis:
The course will provide an introduction to the physics and technology of particle accelerators with focus on proton and ion accelerator technology. The course will include a survey of existing accelerator types and an introduction to transverse and longitudinal beam optics. The course will also include an introduction to the physics and technology of ion sources, will give an overview of radioactive ion beam production, 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, 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. Each lecturer is responsible for about 3-5 lectures.

Final Grade:
Homework (due one week after assignment) – 50% (based on completion and quality)
Mid-term exam (February 26, 2019) – 20%
Final Exam (TBA) – 30%

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

Course outline and lecture synopsis:

Lecture	Date	Lecturer
1	**January 10**	**Rick Baartman** baartman@triumf.ca
Title: Historical overview Linear and Circular accelerators		
Synopsis: Introduction of the basic principles of acceleration and a review of the historical development of accelerators, both linear and circular.		
2	**January 15**	**Rick Baartman** baartman@triumf.ca
Title: Basics of linear optics of beams - transverse beam dynamics		
Synopsis: Coordinate system (Frenet-Serret coordinate systems), Hill's equation, Matrix formalism and the concept of beam emittance will be explained.		
3	**January 17**	**Rick Baartman** baartman@triumf.ca
Title: Introduction into Hamiltonian formalism in beam physics		
Synopsis: Introduction of the Hamiltonian of the electromagnetic field in the correct relativistic description. Principle of the independent variable and canonical coordinate transformation. Example of a quadrupole.		
4	**January 22**	**Rick Baartman** baartman@triumf.ca
Title: Cyclotrons – weak focusing accelerators		
Synopsis: The magnetic resonance is the basic of a family of weak focusing accelerators, the Cyclotrons. An overview of cyclotron principles, technical solutions and applications will be shown.		
5	**January 24**	**Rick Baartman** baartman@triumf.ca
Title: Beam line elements - Magnets (Design and function)		
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.		
6	**January 29**	**Oliver Kester** okester@triumf.ca
Title: FODO structures and periodic lattices		
Synopsis: The principle of periodic focusing structures will be explained, with the example the FODO lattice. Examples of focusing elements for charged particles and the effect of beam line element on the phase space ellipse will be addressed.		
7	**January 31**	**Oliver Kester** okester@triumf.ca
Title: Basics of longitudinal beam dynamics		
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, of dispersion and momentum compaction factor in circular accelerators will be addressed.		
8	**February 5**	**Oliver Kester** okester@triumf.ca
Title: Synchrotrons and storage rings		
Synopsis: The concept of storage rings, synchrotrons and colliders will be explained. Examples of storage rings and colliders will be discussed, in particular the Large Hadron Collider (LHC). The concepts of luminosity and phase space cooling will be explained.		
9	**February 7**	**Oliver Kester** okester@triumf.ca
Title: Vacuum physics 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.		
10	**February 12**	**Oliver Kester** okester@triumf.ca
Title: Beam Instrumentation		
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 instrumentation.		
11	**February 14**	**Friedhelm Ames** ames@triumf.ca
Title: Introduction to Electron and Ion sources		
Synopsis: The basics of electron emission processes and ionization will be explained. This will include thermionic emission, photo emission and electron impact ionization. Electron and ion beam formation will be introduced, and some examples will be presented.		
12	**February 28**	**Friedhelm Ames** ames@triumf.ca
Title: Plasma physics and magnetic confinement		
Synopsis: 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.		
13	**March 5**	**Friedhelm Ames** ames@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 many different types of plasma ion sources available. The most important plasma ion sources as well as sources for negative ions will be presented.		

14	**March 7**	**Friedhelm Ames** ames@triumf.ca
Title: EBIS and ECRIS - sources for highly charged ions		
Synopsis: The principle of highly charged ion generation in the electron cyclotron resonance ion sources (ECRIS) and the electron beam ion sources (EBIS) will be topic of this lecture. In addition, some basics of these ion sources will be discussed.		
15	**March 12**	**Robert Laxdal** lax@triumf.ca
Title: Waveguides and cavities		
Synopsis: For RF-acceleration, wave guides and RF-resonators or cavities are key. The fundamentals of wave guides, cavities and standing electromagnetic wave in such devices will be discussed.		
16	**March 14**	**Robert Laxdal** lax@triumf.ca
Title: Fundamental parameters of RF resonators (Q-value, shunt impedance, skin effect)		
Synopsis: The physics of RF-resonators will be explained, and fundamental parameter of normal and superconducting cavities will be reviewed in this lecture.		
17	**March 19**	**Robert Laxdal** lax@triumf.ca
Title: RF acceleration in periodic structures - Linacs		
Synopsis: RF-acceleration in linac is introduced as well as basic parameters like the transit time factor (TTF). Different type of linac are discussed like DTLs, and high energy linac.		
18	**March 21**	**Robert Laxdal** lax@triumf.ca
Title: Heavy ion accelerators: Radio Frequency Quadrupoles (RFQ), IH-structures, DTLs, SRF cavities		
Synopsis: Motivation for CW and pulsed linacs and different types of cavities like RFQs, IH-structures, Alvarez and coaxial cavities is given.		
19	**March 26**	**Alexander Gottberg** gottberg@triumf.ca
Title: Physics of radioisotope production		
Synopsis: Basics of interaction of beams with matter and according nuclear reactions will be discussed. The introduction to methods for producing short-lived radioisotopes beams, in-flight separation and Radioisotope Separation Online (ISOL) techniques is foreseen as well as techniques for ion beam purification and selection.		
20	**March 28**	**Alexander Gottberg** gottberg@triumf.ca
Title: Accelerator based secondary particle production		
Synopsis: An overview of accelerator driven secondary particle production is reviewed in this lecture. The according beam production and target handling technology will be introduced using examples.		

21	**April 2**	**Alexander Gottberg** gottberg@triumf.ca
Title: Target and ion sources		
Synopsis: An overview of target material and technology for the production of medical and industrial radioisotopes will be given. That includes an overview of target technology for the production of medical and industrial radioisotopes. Chemically selective and high-efficiency ion sources for secondary ion beams are reviewed		
22	**April 4**	**tbd**
Title: Modern concepts of ultra high gradient acceleration		
Synopsis:		