Riga Technical University

University of Latvia

RTU/LU Course

General data

Code	HEP002
Course title	Accelerator Technology
Course status in the programme	Obligatory
Course level	Doctoral Studies
Course type	Academic
Field of study	Technology
Responsible instructor	Prof. Toms Torims
Volume of the course: parts and credits points	1 Part, 8 Credits points
Language of instruction	EN
Possibility of distance learning	Not planned
Abstract	
Goals and objectives of the course in terms of competences and skills	- A brief overview of different types of accelerators and the transport of particles. Includes a short history of accelerators. - Overview of the basic principles of Linear Accelerators and the required components and structures. An introduction to the beam dynamics should cover the main aspects. - Basic concepts of cyclotrons and beam dynamics. The subclasses of different types should be covered. Motivation (recent interest, e.g. medical applications, fission, ADS, ...) in FFAG, combination of cyclotron and synchrotron advantages. Basic principles. - A short review of classical electrodynamics, derivations only where essential. - Arrive at a description of particle motion in electromagnetic fields. Given that simulation and tracking codes play the central role in accelerator design and operation, the concepts should be formulated as an approach based on s-maps. Should allow the extension to non-linear maps in advanced courses. This approach allowing exact tracking, easy analysis and a map-based perturbation theory puts it above any other methods and should be introduced here as a concept. - The physics for any type of magnets is contained in a map representing the element. For any (linear and non-linear elements) introduce a general view how they are obtained, glimpse at the concepts, but details left to advanced course. The maps for common machine elements should be given as input for the following lectures of the course. - Introduce special relativity, main emphasis on applications in beam dynamics. Provide the mathematical tools. - A general concept into systems of particles and description of the properties of the system. Should provide the framework for consistent use in following lectures (mainly to avoid duplicated and/or inconsistent definitions and conventions). - Starting from the linear transfer maps (i.e. matrices) describe the first-order dynamics in beam lines and synchrotrons. Define as a sequence of linear machine components and derive the basic quantities, global quantities (e.g. tune, chromaticity) and local (Twiss parameters, dispersion). Assume no coupling between the planes, but treat the problem in 2D. - Basic concepts of cyclotrons and beam dynamics. The subclasses of different types should be covered. - Motivation (recent interest, e.g. medical applications, fission, ADS, ...) in FFAG, combination of cyclotron and synchrotron advantages. Basic principles. - Together with lecture on ”RF Systems” introduce the acceleration principles, strong emphasis on beam dynamics and required structures. - Twofold: introduce instruments and signal processing. Limitations, advanages and disadvantages of different instruments. Use of the instruments to measure beam parameters, preparation and processing of the data. Presentation for further use. - For the whole theme: properties of synchrotron radiation and impact (negaive and positive effects, applications). Principles of synchrotron radiation, main parameter, e.g. spectra. If time permits, incoherent and coherent radiation. Beam dynamics with radiation together with principles and properties of light sources. - Introduction to multi particle effects and interaction with the environment, concepts of impedance and wake fields. Should give a general overview over different types of collective effects. Mostly phenomenology, details in Advanced Level School, should follow after non-linear dynamics lectures. - Motivation to use colliding beams, very short introduction. Definition of lu- minosity. Discussion of various effects with impact on the luminosity and collider performance. Discussion of various methods to measure luminosty, for different types of machines and particle types. - Beam dynamics of injection and extraction processes. Should include techniques for low loss procedures, different requirements for extraction (e.g. short pulses, high intensity etc.). Consequences for the design. Short discussion of secondary beams and target

	requirements, including very high energy/intensity beams (e.g. spallation sources).
Structure and tasks of independent studies	
Recommended literature	
Course prerequisites	
Courses acquired before	

Course contents

Content	Full- and part-time intramural studies		Part time extramural studies	
	Contact Hours	Indep. work	Contact Hours	Indep. work
Introduction to particle accelerators: basic principles, types, trends. Different types of accelerators: Circular and linear, collider, cooler rings, synchrotron light-sources, medical accelerators, cyclotrons. Accelerator Driven Systems.				
Accelerator components: magnets, FR systems, vacuum, particle sources and diagnostic for current, position and beam size. Beam dynamics.				
Electro-magnetic theory. Article motion in EM fields. Relativity and kinematics of particle beams. Linear accelerators. Transverse linear beam dynamics for synchrotrons and beam lines, all in 2D. Cyclotrons and FFAG. Longitudinal beam dynamics in circular accelerators. RF systems. Linear imperfections.				
Beam instrumentation and diagnostics. Electron beam dynamics - synchrotrons and light sources. Non-linear beam dynamics. Collective and multi particle effects. Luminosity and colliders. Injection, extraction, beam transfer, secondary beams and targets.				
Applications in high-energy physics. Medical and Industrial accelerators. Environmental applications.				
Technological challenges, current R&D and further developments				
Total:				

Learning outcomes and assessment

Learning outcomes	Assessment methods
Knowledge of applications and limitations of different types of accelerators	

Evaluation criteria of study results

Criterion	%
Total:	

Course planning

Part	Semester			CP	ECTS	Hours per Week			Tests			Tests (free choice)		
	Autumn	Spring	Summer			Lectures	Practical	Lab.	Test	Exam	Work	Test	Exam	Work
1.														