

PHYS-751

**Advanced concepts in particle accelerators**

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Cursus	Sem.	Type
Physics		Opt.

Language of teaching	English
Credits	4
Session	
Exam	Oral presentation
Workload	120h
<b>Hours</b>	<b>70</b>
Courses	28
Exercises	14
Project	28
<b>Number of positions</b>	

**Frequency**

Every year

**Remark**

Next time: Spring 2026

**Summary**

Accelerator physics covers a wide range of very exciting topics. This course presents basic physics ideas and the technologies underlying the workings of modern accelerators. An overview of the new ideas and challenges of the possible paths towards the next generation of accelerators will be given.

**Content**

Introduction to Accelerators: historical and conceptual steps pushing technology and energy reach:

- Accelerators at the energy frontier
- Applications in science, medicine and industry

**Accelerator technology and single particle dynamics:**

- Transverse beam dynamics
- Longitudinal beam dynamics
- Synchrotron radiation

**Non-linear dynamics: phenomenology, tools and methods:**

- Multipole expansion and term in Hamiltonians
- Wanted/unwanted non-linearities, tracking with non-linear elements, symplecticity
- Tune effects and Non-linear resonances
- Dynamic aperture
- Linear Normal Forms and analysis, Lie transformations

**Collective effects in beam dynamics:**

- Impedance and wakefields
- Beam instabilities in linear and circular accelerators
- Space charge
- Beam-beam effects, luminosity and colliders

- Free electron lasers

**Advanced Acceleration concepts:**

- Acceleration and technology today
- Dielectric laser accelerators
- Plasma wakefield accelerators
- Laser interactions in free electron lasers and storage rings
- Advanced concepts for the acceleration of protons and other ions.

Application of AI/ML to accelerator operation and design.  
Visits to the CERN and PSI accelerator complex.

**Note****Auditors should contact the lecturers before subscribing.**

In-person class and exercises. Simulation project to design an accelerator.  
Class limited to 40 participants.

**Learning Prerequisites****Required courses**

General basic courses of electromagnetism and classical mechanics

**Expected student activities**

to design a basic accelerator and to model and understand the dynamics of charged particles through the building blocks covered in the lectures (i.e. magnets, accelerating cavities, electron clouds, collisions)

**Resources****Moodle Link**

- <https://go.epfl.ch/PHYS-751>