PHYS-751

# Advanced concepts in particle accelerators

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| Cursus | Sem. | Type |
|---|---|---|
| Physics | | Opt. |

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|---|---|
| Language of teaching | English |
| Credits | 4 |
| Session | |
| Exam | Oral presentation |
| Workload | 120h |
| **Hours** | **70** |
| Courses | 28 |
| Exercises | 14 |
| Project | 28 |
| **Number of positions** | |

## Frequency

Every year

## Remark

Next time: Spring

## 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)