Warsaw University of Technology | Doctoral School No. 3

Course offered in the Doctoral School No. 3 – Spring semester of the 2021/2022 academic year

TITLE
Introduction to particle accelerators
CONDUCTING UNIT
Doctoral School No. 3
SCIENTIFIC DISCIPLINE
Physical sciences
IMPLEMENTING UNIT
105000 - Faculty of Physics
SUMMARY DESCRIPTION
The course covers a broad overview of modern particle accelerators. Physics standing behind accelerators are taught at lectures of linear and nonlinear beam dynamics. These concepts are then practiced during the tutorials with an active use of common software tools for particle accelerators. Participants follow examples prepared by the lecturer and are asked to complete the related tasks. The most important subsystems and components of modern particle accelerators are discussed in the following lectures. Applications of particle accelerators are discussed in detail including colliders used for physics, but also synchrotron light sources, industrial accelerators and medical accelerators. An active participation of students is provided by the means of seminars dedicated to students' presentation on a chosen subject. A special attention will be given not only to the selection of content by the participants but also to improvement of their presentation skills and techniques.
FULL DESCRIPTION
The course is intended to give the participants a broad overview of modern particle accelerators, used not only for research, but also for industrial and medical applications. An attention will be also given to teach the common conventions and nomenclature of particle accelerators. The first four lectures are dedicated to teach the physics standing behind their operation. This contains linear beam dynamics, transverse and longitudinal, including

the machine elements responsible for the given physical effect. The nonlinear beam dynamics, including common machine imperfections and correction methods is also discussed. The concepts taught at these four lectures are then practiced during the four tutorials with an active use of common software tools for particle accelerators. Participants follow examples prepared by the lecturer and are asked to complete the related tasks.
The most important subsystems and components of modern particle accelerators are discussed in the following lectures. Applications of particle accelerators are discussed in detail including colliders used for physics, but also synchrotron light sources, industrial and medical accelerators.
An active participation of students is provided by the series of seminars dedicated to students' presentation on a chosen subject. A special attention will be given not only to the selection of content by the participants but also to improvement of their presentation skills and techniques.

Detailed plan of the lecture:

1. Overview of origin and development of particle accelerators. Categories and examples of accelerators.
2. Linear transverse beam dynamics.
3. Linear longitudinal beam dynamics.
4. Nonlinear beam dynamics, imperfections, correction methods.
5. Diagnostics and instrumentation.
6. Collimation and machine protection.
7. Industrial applications of accelerators.
8. Medical applications accelerators.

Tutorials:

1. Download, installation and configuration of the MAD-X (Methodical Accelerator Design) program for accelerator design. Getting familiar with the code syntax and logics with an active use of documentation. Understanding responses of the program.
2. Creating an accelerator model that illustrates concepts of the lecture.
3. Advanced methods of the program with examples of practical use.
4. Overview of codes for particle tracking (PTC, SixTrack).

Seminars:
Two or three classes, depending on the number of participants, dedicated to students' presentations. The list of possible subjects will be available. Students are also welcome to propose their own subject.

LITERATURE

1. Klaus Wille, The Physics of Particle Accelerators: An Introduction.
2. Helmut Wiedemann, Particle Accelerator Physics.
3. Handbook of Accelerator Physics and Engineering edited by Alex Chao, M. Tigner.
4. The MAD-X Program, User's Reference Manual
http://madx.web.cern.ch/madx/releases/last-rel/madxuguide.pdf

LEARNING OUTCOMES
Participants learn the basics of particle accelerators including the physics standing behind their operation and the most important components and subsystems of modern particle accelerators. Participants acquire the common conventions and nomenclature facilitating communication with accelerators community. Interdisciplinary aspects of modern accelerators are discussed making participants aware of research and engineering fields involved into design, operation and upgrade of particle accelerators. Participants learn about the most common applications of particle accelerators, not only for research but also in industry and medicine. During the tutorials, participants learn how to operate the most common software tools used for modelling and developing particle accelerators. During the seminars, participants practice public scientific presentations. An emphasis is given not only to the selection of content but also to presentation skills and techniques.
ASSESSMENT METHODS AND CITERIA; COURSE COMPLETION FORM
Participants can collect 100 points: 40 points by completing the task related to tutorials and 60 points for presenting at the seminar. Share of points for the presentation is the following: selection of material (20), logical presentation flow (10), slides quality (10), keeping audience interested (10), answers to questions (10). The final grade depends on the number of collected points: -51-60: 3.0 -61-70: 3.5 -71-80: 4.0 -81-90: 4.5 -91-100: 5.0.

LANGUAGE OF THE COURSE	ECTS CREDITS
English	2

TYPE OF CLASSES	NUMBER OF HOURS	COURSE INSTRUCTOR
Lecture	16	Marcin Patecki, dr inż.
Laboratory	8	Marcin Patecki, dr inż.
Seminar	6	Marcin Patecki, dr inż.

ADDITIONAL INFORMATION
The course is realized within the SEED Project – NAWA STER Programme. Therefore, in order to take part in it, each participant is obliged to deliver to the PhD Students' Office the Declaration of the Project Participant concerning personal data. The document must be submitted until **March 1, 2022.** The document can be found here: https://www.sd.pw.edu.pl/sd_en/SEED-NAWA-STER