Universitat Autònoma de Barcelona

2022/2023

Accelerator Physics

Code: 104048
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	OT	4	2

Contact

Name: Caterina Biscari
Email: caterina.biscari@uab.cat

Use of Languages

Principal working language: spanish (spa)
Some groups entirely in English: No
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

External teachers

Gabriele Benedetti

Prerequisites

There are no formal prerequisites but knowledge of classical mechanics, electromagnetism and special relativity are assumed

Objectives and Contextualisation

It is an introduction to the physics of particle accelerators and their applications, with special emphasis on the sources of synchrotron light.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics
- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.

- Plan and perform, using appropriate methods, study, research or experimental measure and interpret and present the results.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Using appropriate methods, plan and carry out a study or theoretical research and interpret and present the results
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project
- Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Learning Outcomes

1. Calculate the frequency of revolution in synchrotrons based on particle types and their energy
2. Calculate the luminosity of a hadron, differentiating between circular and linear hadrons.
3. Carry out the basic design of an optical accumulation ring or synchrotron defining the Twiss parameters and the characteristics of radio frequency
4. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
5. Define the main characteristics of a hadron depending on the energy and luminosity required.
6. Demonstrate an understanding of the bases to the applications of a synchrotron light source
7. Demonstrate an understanding of the basics of plasma acceleration
8. Describe the basics of dynamic transverse and longitudinal beam
9. Describe the different types of magnets, from permanent magnets, ferromagnetic and superconductors used in accelerators
10. Describe the different types of particle accelerators currently in use: Linacre, cyclotrons, synchrotrons, etc. and their major applications
11. Describe the technology of radio frequency cavities
12. Determine type of photon source based on applications, differentiating between dipoles, wigglers and undulators
13. Explain the explicit or implicit code of practice of one's own area of knowledge.
14. Identify situations in which a change or improvement is needed.
15. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.
16. Measure the quality of the magnetic field for magnets
17. Understand the different types of accelerators, radiation-emitting equipment and radioactive sources for medical applications.
18. Use control-room instrumentation for measuring emittance and energy spread at the Linac
19. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
20. Use matrix treatment in the definition of Twiss parameters.
21. Use simulation codes for dynamic-opening calculations.
22. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
23. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.
24. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals

Content

Introduction to accelerators and their applications.

Principles of acceleration and transport of particle beams.

Basic concepts of radio frequency, magnet and vacuum systems.

Description of the transversal and longitudinal dynamics of particle beams and the characteristics of the synchrotron radiation.

Description of the different types of accelerators, with more emphasis on the synchrotron light sources and their usefulness.

Basic concepts of the simulation of beam dynamics programs.

Two experimental practices in the Alba Synchrotron.

Methodology

The course is structured in theoretical classes (30 hours), completion of exercises (9 hours) and completion of experimental work (10 hours)

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Experimental sessions at ALBA	10	0.4	
Theory lessons	30	1.2	
Tutoring on solving exercises	9	0.36	
Type: Autonomous			
Elaboration of a report on the experimental sessions	9	0.36	
Solving problems	16	0.64	
Study	58	2.32	

Assessment

Partial exams 1 and 2 (40% + 40% of the final grade) done in the middle and end of the semester.
Report on experimental work (20% of the final grade)
The examination of recovery allows to improve the results of the partial e

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes

First partial	40%	3	0.12	1, 4, 8, 10, 9, 13, 24, 15, 14, 19, 22, 23, 20
Recovery Exam	80%	3	0.12	1, 2, 4, 17, 7, 6, 5, 8, 10, 9, 11, 12, 13, 24, 15, 14, 16, 19, 3, 22, 23, 21, 20, 18
Report on experimental sessions	20%	9	0.36	1, 4, 24, 14, 16, 19, 3, 22, 23, 21, 20, 18
Second partial	40%	3	0.12	1, 2, 4, 17, 7, 6, 5, 11, 12, 13, 24, 15, 14, 19, 22, 23, 20

Bibliography

http://cds.cern.ch/record/425460/files/CERN-2005-004.pdf

http://cds.cern.ch/record/603056/files/full_document.pdf

Software

OPA - Optics Design for Accelerators - Free (PSI) - will be provided during the lectures