Course guide
295115 - 295II135 - Electron Beam Applications

Last modified: 04/06/2026

Unit in charge: Barcelona East School of Engineering
Teaching unit: 748 - FIS - Department of Physics.
713 - EQ - Department of Chemical Engineering.
702 - CEM - Department of Materials Science and Engineering.

Degree: MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019). (Optional subject).

Academic year: 2026 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: YOURI ALEXANDROVICH KOUBYCHINE MERKULOV

Others:

PRIOR SKILLS

Knowledge of basics of physics and electromagnetism

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMUEII-13. Design industrial applications that use physical-chemical processes that optimize the efficiency and sustainability of the systems. (Specific competence of the Efficient Systems specialty).

Generical:
CGMUEII-01. Participate in technological innovation projects in multidisciplinary problems, applying mathematical, analytical, scientific, instrumental, technological and management knowledge.
CGMUEII-05. To communicate hypotheses, procedures and results to specialized and non-specialized audiences in a clear and unambiguous way, both orally and through reports and diagrams, in the context of the development of technical solutions for problems of an interdisciplinary nature.

Transversal:
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

Theory classes and monographic seminars by invited speakers
Learning based in carrying out mini-projects (work in small groups) and solution of exercises (individual work)
Practical works in laboratory
Learning on basis of research papers (individual work) and their presentation and discussion in class

LEARNING OBJECTIVES OF THE SUBJECT

Basic knowledge of principles of operation of particle accelerators.
Knowledge of main applications of electron accelerators.
Knowledge of experimental technics with X rays de bremsstrahlung and synchrotron radiation.

STUDY LOAD

Type	Hours	Percentage
Hours small group	21,0	14.00
Hours large group	21,0	14.00
Self study	108,0	72.00

Total learning time: 150 h

CONTENTS

Electron accelerators

Description:
1.1 Accelerators, types and applications.
1.2 Methods of acceleration. Linacs.
1.3 Magnets and beam bending.
1.4 Beam characteristics.
1.5 Beam dynamics. Simulations with MADX.
1.6 Types of accelerators and their subsystems.
1.7 Examples of design of subsystems of electron accelerators.
1.8 Radiation protection and shielding.

Specific objectives:
- Learn main principles of operation of particle accelerators.
- Learn and be able to check the main condition of accelerator stable operation
- Be able to calculate the main parameters of an electron accelerator and characteristics of the generated beam

Related activities:
Activity 1. Mini-project: Accelerator design project (4h + 20h autonomous work)
Practical work: Radiation measurements at laboratory (2h + 6h autonomous work)

Full-or-part-time: 66h
Theory classes: 18h
Laboratory classes: 2h
Self study : 46h

Applications of particle accelerators

Description:
2.1 Sterilization and material irradiation.
2.2 Generation of bremsstrahlung radiation.
2.3 Medical applications: Radiotherapy, isotope production.
2.4 Industrial radiography and cargo inspection.
2.5 Generation of synchrotron radiation.

Specific objectives:
- Learn the main applications of electron beams
- Learn physical principles and methods of generation of electromagnetic radiations in electron accelerators
- Learn main characteristics of X rays generated by an electron beam and their applications

Related activities:
Seminar: Alba synchrotron (2h)
Seminar: Radiotherapy with accelerators (2h)

Full-or-part-time: 18h
Theory classes: 6h
Self study : 12h

Experiments with synchrotron radiation

Description:
3.1 Main experimental techniques.
3.2 Experiments in chemistry.
3.3 Experimental study of materials.
3.4 New synchrotron radiation sources, Thomson scattering facilities, energy recovery linacs (ERLs).

Specific objectives:
- Learn the main technics of use of the synchrotron radiation in experiments in the material science, chemistry and biomedicine.
- Learn to perform the data analysis of results of X-ray dispersion in material studies.
- Learn principles of operation of photoelectric spectrometer.

Related activities:
Practical work: Analysis of data of an experiment at the Alba synchrotron(4h + 10h autonomous work)
Practical work: Photoelectric spectrometer (at the Centre de Recerca Multiescala) (2h + 4h autonomous work)

Full-or-part-time: 38h
Theory classes: 8h
Laboratory classes: 6h
Self study : 24h

GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

Assessment of individual works (20%)
Assessment of mini-project report (15%)
Assessment of laboratory practical works (20%)
Assessment of seminar given by student (5%)
Final exam (40%)

EXAMINATION RULES.

The exams are individuals.
Solution of home exercises is individual work, students deliver reports with solutions.
At the end of each practical work or laboratory work students deliver a report.
The mini-projects are carried out in small groups and consist in a study and calculations defined in the project description. Once the project is finished the groups deliver reports of obtained results.

BIBLIOGRAPHY

Basic:
- Humphries, Stanley. Principles of charged particle acceleration. Los Alamos: R Books, 2012. ISBN 0471878782.
- Wiedemann, Helmut. Particle accelerator physics [on line]. Berlin/Heidelberg, DEU: Springer, 2007 [Consultation: 15/04/2020]. Available on: http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10230338. ISBN 9783540490456.

RESOURCES

Other resources:
J. Rossbach, P. Schmüser, "Basic course on accelerator optics". CAS 2005, pp. 17-88