



## Course guide

### 295115 - 295II135 - Electron Beam Applications

Last modified: 02/10/2025

**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:** 2025    **ECTS Credits:** 6.0    **Languages:** English

#### LECTURER

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**Coordinating lecturer:** YOURI ALEXANDROVICH KOUBYCHINE MERKULOV

**Others:**

#### PRIOR SKILLS

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Knowledge of basics of physics and electromagnetism

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**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).

**General:**

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

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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

- 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.

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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

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### 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

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### Other resources:

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