# Course guide
# 295924 - ESTAMHE - Emerging Science and Technologies for Advanced Materials, Health & Environment

**Last modified:** 24/06/2026

**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:** BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Optional subject).

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

## LECTURER

**Coordinating lecturer:** YOURI ALEXANDROVICH KOUBYCHINE MERKULOV

**Others:** Pere Bruna (Física 748)
Maria Pau Ginebra (Ciència i Enginyeria de Materials (CEM) 702)
Jordi Llorca (Enginyeria Química 713)

## PRIOR SKILLS

- Basic general physics
- General background in instrumentation
- Basics of probability and data analysis
- Basics in programming

## REQUIREMENTS

- Basic general physics
- General background in instrumentation
- Basics of probability and data analysis
- Basics in programming

## TEACHING METHODOLOGY

- Theory classes
- Monographic seminars by invited speakers
- Solution of exercises (individual work)
- Practical works in laboratory,
- Project-based learning (work in small groups)

## LEARNING OBJECTIVES OF THE SUBJECT

- Learn main principles of operation of particle accelerators and main engineering aspects.
- Get acquainted with main applications of electron beams in medicine, materials science, chemistry and industry.
- Get acquainted with particle accelerators, specifically synchrotrons, used for various fields of research.
- Learn main experimental technics used at synchrotron radiation beamlines.
- Learn techniques of analysis of experimental data in materials science and chemistry.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours large group | 60,0 | 100.00 |

**Total learning time:** 60 h

## CONTENTS

### 1. Particle accelerators

**Description:**
1.1 Introduction to particle accelerators
1.2 Physical principles of operation and engineering aspects
1.3 Large facilities: ALBA synchrotron and CERN collider
1.4 Review of accelerators research and industrial applications

**Related activities:**
Theory classes
Solution of exercises
Activity 1. Design of an electron storage ring (analytically or with AT MATLAB)
Activity 2. Practical work at the ALBA synchrotron

**Full-or-part-time:** 37h 30m
Theory classes: 23h 30m
Guided activities: 8h
Self study : 6h

### 2. Synchrotron radiation

**Description:**
2.1 Fundamental concepts of synchrotron radiation
2.2 The Nature of Light: Methods of generation
2.3 Experimental techniques in chemistry and materials science
2.4 Discovery of new materials

**Related activities:**
Theory classes
Solution of exercises
Activity 3. Laboratory practice X-ray photoelectron spectroscopy (XPS)
Activity 4. Processing data of an experiment with synchrotron radiation

**Full-or-part-time:** 34h 30m
Theory classes: 15h
Guided activities: 8h
Self study : 11h 30m

### 3. Applications of electron beams

**Description:**
3.1 Electron-matter interactions
3.2 Electron beams for discovery of new materials
3.3 Green industry: sterilization, industrial radiography, flue gas cleaning
3.4 Medical applications: radiation therapy and nuclear medicine

**Related activities:**
Theory classes
Solution of exercises
Activity 5. Presentation of an article

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

## GRADING SYSTEM

Individual assignments: 30%
Laboratory practices: 30%
Projects: 25%
Seminar given by student: 15%

## BIBLIOGRAPHY

**Basic:**
- Chao, Alex; Chou, Weiren. Reviews of accelerator science and technology. Singapore: World Scientific, 2008-2009. ISBN 9789814299343.
- Rossbach, J., Schmüser, P.. "Basic course on accelerator optics". CERN Accelerator School 2005 [on line]. CERN, 2005. Available on: https://cds.cern.ch/record/247501?ln=ca.- Chastain, J., King, Jr. R.C.,Eds.. Handbook of X-ray Photoelectron Spectroscopy [on line]. Minnesota, US: Physical Electronics, Inc., 1995Available on: https://mmrc.caltech.edu/XPS%20Info/XPS%201995%20Phi.pdf. ISBN 0-9648124-1-X.
- Bayguinov, P.O. et al.. "Assaying three-dimensional cellular architecture using X-ray tomographic and correlated imaging approaches". Journal of Biological Chemistry [on line]. vol. 295 (46), pp. 15782-15793Available on: DOI 10.1074/jbc.REV120.009633.

## RESOURCES

**Other resources:**
Course presentations (at the UPC Atenea digital campus)
Manual of the practical works (at the UPC Atenea digital campus)
Bruce Ravel's XAS Education Materials at https://bruceravel.github.io/XAS-Education/ />