Universitat Autònoma de Barcelona

Radiation Physics

Code: 100186
ECTS Credits: 6

2025/2026

Degree	Type	Year
Physics	OT	4

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

It is recommended that, in addition to the general knowledge taught in the first cycle subjects, they have previous knowledge of the bases of atomic physics and nuclear physics.

Objectives and Contextualisation

- Differentiate the ionizing radiations of the non-ionizing ones

- Study the processes of nuclear disintegration, the law of radioactive activity and the series of radioactive decay

- To know the physical principles of the interaction of any type of ionizing radiation with matter

- Apply these physical principles to the detection of ionizing radiation

- Study and differentiate the different types of radiation detectors and electronics associated with detection.

- Have knowledge of the different fields of application of ionizing radiation: environment, medicine and industry.

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. Analyse levels of radiation from a set of measurements obtained in a real installation.
2. Calculate approximately the suitable shielding for radiation protection in specific practical situations.
3. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
4. Combine information provided by several detectors to obtain information integrated from the radiation characteristics analysed.
5. 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.
6. Demonstrate an understanding of the bases to radiation detectors used in imaging for diagnosis and medical treatment.
7. Demonstrate an understanding of the bases to the techniques and instruments of the production of ionizing radiation used in medicine, industry and research.
8. Describe the physical principles underlying the detection of ionizing radiation.
9. Determine the basic characteristics of, and carry out measurements for, alpha, beta and gamma radiation in the laboratory.
10. Determine the most suitable type of detector for each type of ionizing radiation.
11. Explain the explicit or implicit code of practice of one's own area of knowledge.
12. Identify situations in which a change or improvement is needed.
13. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.
14. Obtain the Bethe-Bloch equation and apply it to the interaction of particles charged with matter.

15. Obtain the equations for the Compton effect, the Compton cross-section and absorption coefficients and attenuation, and apply these to the interaction of photons with matter.
16. Proceed to the calibration of different types of detectors based on results in metrological facilities.
17. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
18. Use numerical simulation to calculate the transport of radiation through matter.
19. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
20. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Content

1.- Introduction

- Radioactivity, since 1890.
- Atoms
    - Atomic structure and atomic radiation
    - Nuclei
        - The nucleus and the radioactivity. Disintegration diagrams. Alpha, beta and gamma radiation.
        - Radioactivity
            - Activity and law of radioactive decay. Disintegration series. Equilibrium

2.- Radiation-matter interaction

- Interaction of particles loaded with matter
    - Heavy particles: collision mechanisms. Primary and secondary ionization. Power of braking. Semiclassic treatment: Bethe-Bloch equation. Energies of excitement. Reach Radiation Cerenkov. Limitations of semiclassic treatment.
    - Electrons: Mechanisms of loss of energy: collisions and emission of braking radiation. Reach
    - Tracks of charged particles: Delta rays. Restricted Energy Loss. Linear energy transfer (LET). Specific ionization. Fluctuations in energy and range. Multiple Coulomb Dispersion.
    - Interaction of photons with matter.
        - Photoelectric effect. Compton effect. Pair production Photonuclear reactions. Dimension coefficients and absorption coefficients.
        - Neutrons.
            - Neutron sources. Neutron classification. Mechanisms of interaction with the subject. Elastic dispersion Reactions and power threshold. Activation. Fission. Criticity.

3.- Radiation detectors

- Counting statistics
    - Statistical models. Uncertainty. Detection límit
    - General properties of detectors
        - Modes of operation. Energy Resolution. Detection Efficiency. Dead time Resolution time
        - Gas detectors
            - Ionization chambers.
            - Proportional Counters: Multiplication. Operation of proportional counters. Efficiency of detection and counting curves.
            - Geiger-Müller Counters: Download. Temporary behaviorDesign particulars. Efficiency
            - Scintillation detectors
                - Solid scintillators. Liquid scintillators. Photomultipliers and photodiodes. Spectrometry. Response to gamma radiation and neutrons

- Semiconductors
    - Si Diodes Ge detectors Other semiconductors. Avalanche detectors.
    - Neutron detectors
        - Slow neutron detection. Fast neutron detection. Spectrometry. Detectors based on activation.
        - Other detectors
            - Photographic emulsions Thermoluminescent dosimeters. Trace Detectors. Cerenkov Detectors. Fog rooms. Bubble Chambers
            - Nuclear electronics
                - Pulse processing Impedances Linear functions and logic functions. Digital devices Multi-channel analyzers

4.- Applications

- Radioprotection
    - Dosimetry Magnitudes and units. Dose calculation. Biological effects of radiation. Radiation protection: external radiation and internal dosimetry
    - Industrial Applications
        - Measures of thicknesses. Density measurements Level control. Quality control. Sterilization.
        - Medical Applications
            - Diagnostic tests (TAC). Production of radiopharmaceuticals. PET Radiation therapy treatments: LINACs and hadron therapy.
            - Natural environment:
                - Use of tracers. Environmental protection Geocronology.

5.- Demonstrations (draft list)

- Computer tools in radiation physics (classroom)
- Geiger-Müller counter: characteristic curve, resolution time and geometric factor.
- Determination of detection efficiency
- Detection of alpha particles with a semiconductor surface barrier detector.
- Absorption and backscattering of beta radiation
- Gamma Spectrometry with solid flashlight NaI (Tl). Calibration in energy and study of spectra
- Neutron spectrometry: the active system (3He) and the passive system (activation of 197Au) of the Bonner spheres of the UAB.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Laboratory demonstrations	7	0.28	
Problems solving at the classroom/virtually	12	0.48	
Theory lectures (presential/virtual)	30	1.2	
Type: Autonomous			
Bibliographic tasks and problems	15	0.6	
Information reasearch and studying	61	2.44	

Preparation of the demonstration's reports	16	0.64

The subject has face-to-face classes of theory, problems and laboratory practices. It is highly recommended to attend classes of theory and problems, and it is mandatory to assist and perform the laboratory practices.

During the course, the carrying out of supervised activities, both of a more theoretical nature (bibliographic research and work realization) and of a practical nature (problem solving and experimental data search) will be considered.

The student will have to devote an important part of the time in the extension of the knowledge given in class and in the personal study.

- Presentiallity

Theory and problem classes will be held presentially.

Laboratory practices will be presential.

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.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Control tests during the course	20%	1	0.04	2, 4, 7, 6, 8, 10, 13, 12, 14, 15, 19
Evaluation of demonstrations and their reports	20%	0	0	4, 5, 6, 10, 9, 11, 1, 13, 12, 16, 17, 20
Evaluation of supervises tasks and problems	10%	0	0	5, 7, 6, 3, 1, 12, 17, 19, 18
Repesca: recovery of the two partial examinations	50%	3	0.12	2, 4, 7, 6, 8, 10, 14, 15, 17, 18
Two partial examinations: 1) Interaction of radiation with matter; 2) Radiation detectors and applications. Each part has a weight of between 20% and 30%	50%	5	0.2	2, 4, 7, 6, 8, 10, 1, 14, 15, 17, 18

The evaluation of the subject will be carried out with four types of activities:

1.- Practical theoretical examinations: There will be two partial exams with questions and problems about the syllabus taught in class or that the student has worked throughout the course that have a global weight of 50%. The partial exams are carried out on the dates reserved for this activity in the calendar of the degree of physics. Each partial exam has a weight between 20% and 30% on the final grade. The repesca test, on the scheduled date for the physical fitness calendar, allows students who have not passed one or both of the partials to have a second chance to do so. The possibility is not for students that have passed the course to submit to the repesca test to upload the note.

2.- Control and continuous evaluation tests that will be carried out during the course presentially. Because of its nature, repesca is not possible. Typically 3 tests are performed throughout the course. The overall weight of this activity is 20%.

3.- Evaluation of laboratory practices. Based on the corresponding reports and the evaluation carried out by the laboratory professors during the performance of the practices. The accomplishment of the practices is an indispensable requirement to surpass the subject. The weight of this activity is 20%.

4.- Evaluation of the directed work and problems. With a global weight on the 10% note.

In order to pass the course, it is mandatory to note all the activities that can be evaluated.

Single assessment modality

Students who take the single assessment modality will have to do a final exam for the subject that will consist of test-type questions, text questions and problems. The weight for this exam will be 80%.

The remaining 20% will come from the evaluation of the laboratory practices, which attendance and completion are mandatory in the same sessions scheduled for the rest of the students. The delivery date of the laboratory report will be, for this students, the same day as the exam.

If the subject is not passed, there will be a second opportunity for 80% of the grade corresponding to the exam. The 20% corresponding to the laboratory practices will have no second opportunity.

The review of the final qualification follows the same procedure as for the continuous assessment

Bibliography

- G.F. Knoll. *Radiation Detection and Measurement*. John Wiley & sons, Inc (1999).
- G.C Lowenthal, P.L. Airey. *Practical Applications of Radioactivity and Nuclear Radiatilons*. Cambridge University Press (2001)
- J.E. Martin, Physics for Radiation Protection: A Handbook. Wiley-VCH (2006).
- J.E. Turner. *Atoms, Radiation, and Radiation Protection.4th edition.* John Wiley & sons, Inc (2023)

Software

Specific software is not required

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan/Spanish	first semester	afternoon
(PLAB) Practical laboratories	1	Catalan/Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	2	Catalan/Spanish	first semester	morning-mixed
(TE) Theory	1	Catalan/Spanish	first semester	afternoon