# SUBJECT TEACHING GUIDE

## G75 - Radiophysics

## Double Degree in Physics and Mathematics
## Degree in Physics
## Degree in Physics

Academic year 2024-2025

| 1. IDENTIFYING DATA | | | | | |
|---|---|---|---|---|---|
| Degree | Double Degree in Physics and Mathematics<br>Degree in Physics<br>Degree in Physics | | | Type and Year | Optional. Year 5<br>Optional. Year 4 |
| Faculty | Faculty of Sciences | | | | |
| Discipline | Subject Area: Radiophysics<br>Mention in Applied Physics | | | | |
| Course unit title and code | G75 - Radiophysics | | | | |
| Number of ECTS credits allocated | 6 | Term | | Semester based (1) | |
| Web | https://moodle.unican.es/course/view.php?id=7840 | | | | |
| Language of instruction | Spanish | English Friendly | Yes | Mode of delivery | Face-to-face |



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| Department | DPTO. FISICA MODERNA |
| Name of lecturer | JESUS MANUEL VIZAN GARCIA |
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| Other lecturers | CARLOS SAINZ FERNANDEZ<br>ALICIA CALDERON TAZON<br>NICOLAS FERREIROS VAZQUEZ<br>ENRIQUE MARQUES FRAGUELA<br>CELESTINO RODRÍGUEZ COBO |

| 3.1 LEARNING OUTCOMES |
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| - Understanding the impact of ionizing radiation in areas such as Medicine or Environment. |
| - How to handle the relevant statistical parameters when studying a radioactive process. |
| - Natural and artificial sources of radiation. |
| - Knowledge of the principles of the simplest radiation detectors. |
| - Estimation of the pertinent radiological protection measures. |
| - Understanding the forms of clinical use of radiation. |
| - Knowledge of the uses of radioactivity in environmental measurements. |

| 4. OBJECTIVES |
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| Knowledge of the statistical methods to analyze the radioactivity measurements.<br>Practical knowledge of the Minimum Detectable Activity, MDA. |
| Natural radioactive chains and secular equilibrium. Origin of the different radiation sources (cosmogenic and anthropogenic) of interest in the evaluation of environmental radiation. |
| Knowledge of the main aspects of the interaction of ionizing radiation and neutrons with matter.<br>Knowledge of the fundamental aspects of the interaction of radiation with living organisms and their influence in the formation of radiological images. |
| Knowledge of the properties of the following detectors: Ionization chamber, Geiger, scintillators and solid state semiconductor detectors.<br>Knowledge of the concept of Absolute Efficiency of a Detector. |
| Knowledge of the magnitudes and units used in radioactive dosimetry and radiological protection.<br>Legal regulations of the Radiological Protection. |
| Radiological protection rules to be applied in diagnosis and therapeutic processes which involve ionizing radiations.<br>Analysis of the risk/benefit, from a dosimetric point of view, of diagnosis and therapy processes that use ionizing radiations. |
| Physical bases and main instruments and methods for the clinical use of ionizing radiations in diagnosis and therapy. |
| Radiation measurements as a tool in environmental evaluations (paleoclimate, drift and sedimentation, radon in the environment, geochronology). |

| 6. SUBJECT PROGRAM | |
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| CONTENTS | |
| 1 | Unstable nuclei and radioactivity. The origin of radioactive nuclei. Environmental radioactivity. Radioactive chains. Cosmic rays. Applications: Geochronology, Chronological dating, Sedimentation rate, Paleoclimatology. Fundamental law of radioactive decay and secular equilibrium. Radioactive decay and secular equilibrium. Neutron activation. Radon in the environment.<br>Radioactive decay and secular equilibrium. Neutron activation. |
| 2 | Statistical methods applied to radioactivity measurements. Binomial, Poisson and Gauss distributions. Mean and variance. Minimum detectable activity, MDA. |
| 3 | Interaction of radiation with matter. Stopping power and range for heavy charged particles. Range and bremsstrahlung radiation associated with beta radiation. Mass absorption coefficient for beta particles. |
| 3.1 | Alpha and beta particles attenuation across a material. |
| 3.2 | Interactions of photons with matter: Photoelectric, Compton and pair production effects. Total linear and mass absorption coefficient.<br>Interactions of neutrons with matter. |
| 4 | Radiation detectors. Gas ionizing detectors: Ionization chamber, proportional counter and Geiger-Müller detectors. Dead time. Efficiency. |
| 4.1 | Scintillator detectors: Efficiency and resolution.<br>Semiconductor detectors: n-p unions, depleted region.<br>High purity Germanium detectors: Resolution and efficiency.<br>Neutron detectors. |
| 5 | Dosimetry with a gamma semiconductor or NaI detector.<br>Calibration, efficiency, resolution of a scintillator detector.<br>Neutron flux, activation of In foils, NaI scintillator detector.<br>Alpha particle attenuation with a americium or uranium source. |
| 6 | Radiological magnitudes and units. Activity. Exposure. Absorbed Dose. Equivalent Dose. Effective Dose. |
| 7 | Medical diagnosis using non-ionizing radiations: Echography. Ultrasound Scan. Magnetic Nuclear Resonance Imaging. |
| 8 | Biological effects of the ionizing radiations. General concepts. Deterministic and stochastic effects. Radiosensitivity. Cell and organ responses to the ionizing radiation. Risk evaluation. |
| 9 | Radiological Protection. Concept, goals and principles. Dose-reduction factors: Distance, time, shielding. Operational radiation protection. |
| 10 | Use of radioactivity in healthcare facilities. Nuclear Medicine, Radiodiagnosis, and Radiotheraphy. |
| 10.1 | Organization of a Radiophysics and Radiological Protection Service. |
| 10.2 | Calculation of shielding parameters in a radiodiagnosis facility. |
| 11 | Guarantee of the quality in medical facilities that use ionizing radiation. |
| 11.1 | Quality control and dose determination for radiodiagnosis patients. |
| 11.2 | Quality control and dose determination for nuclear medicine patients. |
| 11.3 | Quality control and dose determination for radiotherapy patients. |
| 12 | Methodology for the determination of the presence of radiation and radioactive contamination in healthcare facilities. |

## 7. ASSESSMENT METHODS AND CRITERIA

| Description | Type | Final Eval. | Reassessn | % |
|---|---|---|---|---|
| Two partial exams with questions and problems for the evaluation of Chapters 1-2, and 3-5. | Written exam | No | Yes | 30,00 |
| Evaluation of the laboratory work of the first part of the subject with a report and an oral presentation. | Others | Yes | No | 20,00 |
| Final exam. Test questions about the second part of the subject (covering both theory and practical work) for all students. It includes a retake of the Partial Exams of the first part of the subject for those students who did not pass them. | Others | Yes | Yes | 50,00 |
| TOTAL | | | | 100,00 |

Observations

The first part of the subject, Chapters 1-5, will be evaluated with two partial exams, and a written report and an oral presentation about two different laboratory projects. There will be a retake of this first part in the final term exam and in the “extraordinary” exam. The laboratory work that has been negatively evaluated will be examined then by specific questions regarding the corresponding projects.

The second part of the subject, Chapters 6-12, will be evaluated in the final term exam, which will be divided in two parts: theory and practical work. Both will consist of test-like questions with five possible anwers. The retake of this second part would take place in the “extraordinary” exam.

Observations for part-time students

The students must attend to six of the nine practical sessions proposed (eight laboratory and one classroom practical sessions), delivering the corresponding written reports. For each practical session in which the student does not participate, they should complete a report about a topic proposed by the professors. This part represents 40% of the final score.

The students must take the Final Ordinary Exam, obtaining a mark equal or above three over ten. This exam will represent 60% of the final score

## 8. BIBLIOGRAPHY AND TEACHING MATERIALS

BASIC

"Radiation detection and measurement", G. F. Knoll, Ed. Wiley, Second Edition (1989)