SUBJECT TEACHING GUIDE

G75 - Radiophysics

Double Degree in Physics and Mathematics
Degree in Physics

Academic year 2021-2022

1. IDENTIFYING DATA					
Degree	Double Degree in Physics and Mathematics Degree in Physics			Type and Year	Optional. Year 5 Optional. Year 4
Faculty	Faculty of Sciences				
Discipline	Subject Area: Radiophysics 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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3.1 LEARNING OUTCOMES
- An operational knowledge of the following concepts related with a radioactive element: Period, Half Life, Decay Constant, Activity, Specific Activity. Estimation of the errors associated to the radioactive measurements. Calculation of the Minimum Detectable Activity, MDA, for a certain radionuclide from the background counts and the counting time.
- Apply the concepts of stopping power and range to describe the interaction of a charged particle with a material. Use of the graphical tabulation of the stopping power and range as a function of the energy. Experimental determination of the stopping power for alpha particles and the extrapolated range and effective mass attenuation coefficient for electrons and for gamma radiation.
- Experimental analysis of the neutron activation. Quantitative analysis of the presence of some elements by neutron activation.
- Experimental determination of the absolute efficiency of gamma detectors using calibrated samples.
- Radiation and radioactive contamination detection in healthcare facilities. Quality control in hospitals and health facilities where ionizing radiations are in use.
- Shielding calculation for different kinds of radiation. Calculation of the actual doses on patients due to diagnosis or therapy processes.
- Implementation of the Radiological Safety Regulations not only in industrial and healthcare radioactive facilities, but also in the standard protocols of diagnosis and therapy using ionizing radiation.
- Use of ionizing radiation counters and neutron counters. Implementation of the calibration and determination of their efficiencies.

4. OBJECTIVES
Knowledge of the statistical methods to analyze the radioactivity measurements. 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. 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. Knowledge of the concept of Absolute Efficiency of a Detector.
Knowledge of the magnitudes and units used in radioactive dosimetry and radiological protection. Legal regulations of the Radiological Protection.
Radiological protection rules to be applied in diagnosis and therapeutic processes which involve ionizing radiations. 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. COURSE ORGANIZATION

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. 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. 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. Semiconductor detectors: n-p unions, depleted region. High purity Germanium detectors: Resolution and efficiency. Neutron detectors.
5	Dosimetry with a gamma semiconductor or NaI detector. Calibration, efficiency, resolution of a scintillator detector. Neutron flux, activation of In foils, NaI scintillator detector. Alpha particle attenuation with a americium or uranium source.
6	Medical diagnosis using non ionizing radiations: Echography, ultrasound scan. Magnetic Nuclear Resonance imaging.
7	Radiological magnitudes and units. Activity. Exposure. Absorbed Dose. Equivalent Dose. Effective Dose. Dosimetric magnitudes for the personal safeguard. Relevant magnitudes applied to the patient´s safeguard.
8	Biological effects of the ionizing radiations. Cell and organ responses to the ionizing radiation.
8.1	Use of radioactivity in healthcare facilities. Radioactive substances without encapsulation. Radiodiagnosis and Radiotherapy
9	Radiological Protection. Basic principles: Distance, time, shielding. Technical Units and Hospital Services for Radiological Protection. Radiological protection in the Spanish law.
10	Radiological Protection in healthcare facilities for radiodiagnosis, radiotherapy and nuclear medicine. Radiological protection of the patients and of the staff.
10.1	The organigram in a "Radiophysics and Radiological Protection Service" at a Hospital.
10.2	Calculation of shielding parameters.
11	Guarantee of the quality in medical facilities that use ionizing radiation.
12	Quality control in healthcare facilities that use ionizing radiations. Calibration and cross contrast of detectors.
12.1	Practical examples of the quality control in medical facilities where ionizing radiations are in use.
13	Radiation dose to the patients in nuclear medicine, radiotherapy and radiodiagnosis procedures.
13.1	Practical examples of the determination of dose rate on patients.
13.2	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	%
Final exam with basic questions and exercices about Chapters 1 to 5	Written exam	Yes	Yes	0,00
Partial Exam for the evaluation of Chapters 1 to 3	Written exam	No	Yes	15,00
Partial Examination of the Chapters 4 and 5 of the first part: Questions and Problems.	Written exam	No	Yes	15,00
Final Examination. Test questions about the second half of the subject	Others	Yes	Yes	30,00
Test-like exam about the practical work of the second part of the subject.	Others	Yes	Yes	20,00
Oral presentation of one of the experiments performed in de laboratory in the first part of the subjet.	Others	Yes	No	5,00
Two written repports of two diffrent experiments of the first part of the subject.	Work	Yes	Yes	15,00
Partial Examination. Test questions about the second half of the subject. Chapters 6, 7, 8.	Others	No	Yes	0,00
TOTAL				100,00

Observations

Partial exams of questions and problems of Chapters 1-5 (first half) can be recovered both in the Ordinary Final Exam (January/February) and in the Extraordinary (February) Exam. The exams corresponding to the second half, Chapters 6-13 and the corresponding practical work, will be divided in two parts (theory and exam about practical work). They will be test-like exams with questions with five possible answers and they will take place during the Ordinary Final Exam. Additionally, there will be a partial exam around November about Chapters 6-8, which can be retaken at the Ordinary Final Exam.

Two written reports about the experiments of the first part must be completed . One oral presentation of the third experiment must be performed (no report should be presented for this experiment).

Final Extraordinary Exam (February): Written exam with questions about both parts of the subject (60% of the mark). The mark of the laboratory work of the first half will be kept. However, the exam regarding the practical work of the second half can be retaken.

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)