COURSE DATA

Data Subject	
Code	43303
Name	Medical applications of nuclear and particle physics
Cycle	Master's degree
ECTS Credits	6.0
Academic year	2023 - 2024

Study (s)

Degree	Center	Acad. year	Period
2150 - M.D. in Advanced Physics	Faculty of Physics	1	First term

Subject-matter

Degree	Subject-matter	Character
2150 - M.D. in Advanced Physics	4 - Nuclear and particle physics	Optional

Coordination

Name	Department
ZUÑIGA ROMAN, JUAN	180 - Atomic, Molecular and Nuclear Physics

SUMMARY

The Medical Applications of Nuclear and Particle Physics course focuses on the applications of nuclear and particle physics to medicine (such as diagnostic imaging) and biomedical sciences. One of the goals is to provide fundamental knowledge about the physics underlying those imaging techniques based on the detection of ionizing radiation (such as computerized axial tomography (CAT), single photon emission tomography (SPECT), and positron emission tomography (PET).The course also includes a detailed study of the operation of the main detectors used in the different types of imaging modalities. The student will be familiarized with those detector parameters that influence the performance of the scanner and therefore in the quality of the final image. Other new techniques and detectors in the research or development phase will also be introduced. This subject includes the study of those physical phenomena that influence the quality of the reconstructed image. The subject will be completed by addressing the fundamentals of the most used methods in the reconstruction of the tomographic image and its quantitative analysis as well as the description of the main therapeutic techniques. The subject includes 2 ECTS of laboratory sessions that facilitate the student's understanding of the main concepts studied as well as their implementation. These sessions will include, among other activities, the operation with detectors, selection and processing of data, the simulation of physical processes and the reconstruction of the image and its quantification.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

OUTCOMES

2150 - M.D. in Advanced Physics

- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should communicate conclusions and underlying knowledge clearly and unambiguously to both specialized and non-specialized audiences.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- Ser capaz de gestionar información de distintas fuentes bibliográficas especializadas utilizando principalmente bases de datos y publicaciones internacionales en lengua inglesa.
- Saber organizarse para planificar y desarrollar el trabajo dentro de un equipo con eficacia y eficiencia.
- Ostentar la preparación para tomar decisiones correctas en la elección de tareas y en su ordenación temporal en su labor investigadora y/o profesional.
- Poseer la capacidad para el desarrollo de una aptitud crítica ante el aprendizaje que le lleve a plantearse nuevos problemas desde perspectivas no convencionales.
- Estar en disposición para seguir los estudios de doctorado y la realización de un proyecto de tesis doctoral.
- Comprender de una forma sistemática el campo de estudio de la Física y el dominio de las habilidades y métodos de investigación relacionados con dicho campo.

- Concebir, diseñar, poner en práctica y adoptar un proceso sustancial de investigación con seriedad académica.
- Realizar un análisis crítico, evaluación y síntesis de ideas nuevas y complejas en el área de la Física.
- Analizar una situación compleja extrayendo cuales son las cantidades físicas relevantes y ser capaz de reducirla a un modelo parametrizado.
- Evaluar la validez de un modelo o teoría propuesto por otros miembros de la comunidad científica.
- Saber modelizar matemáticamente los problemas físicos sencillos nuevos, conectados con problemas conocidos. Ser capaz de expresar en términos matemáticos nuevas ideas.
- Elaborar una memoria clara y concisa de los resultados de su trabajo y de las conclusiones obtenidas en el área de la Física.
- Exponer y defender públicamente el desarrollo, resultados y conclusiones de su trabajo en el área de la Física.
- Conocer los procesos más importantes de la interacción de la radiación con la materia, las técnicas de detección de la radiación, el funcionamiento de los detectores y la instrumentación utilizada actualmente en los experimentos de Física Nuclear y de Partículas.
- To know the main applications of nanoparticles and nanostructured materials obtained or functionalised using a molecular approach- in magnetism, molecular electronics and biomedicine.

LEARNING OUTCOMES

At the end of the teaching-learning process, the student will have learned to:

1. Know the processes, techniques, detectors and measuring instruments in the field of Nuclear Physics and Particle Physics.

2. Learn to plan, simulate and carry out an experiment.

3. Use computer applications and equipment with ease for data processing and analysis, as well as for the presentation of the results and reports.

4. Know the main applications of Nuclear and Particle Physics and be able to intuit new applications.

5. Know the type of accelerator needed for a given experiment or application.

6. Know the main medical imaging systems and techniques and their applications.

7. Learn the detailed operation of radiation detectors used for diagnosis and therapy.

8. Apply the knowledge acquired to different practical cases.

9. Understand the complete process of obtaining the image, from the detection of radiation to its visualization and the effect of the underlying physical phenomena.

10. Being able to simulate the interaction of particles through matter using Monte Carlo code and interpret the data obtained.

DESCRIPTION OF CONTENTS

1. Introduction

a. Introduction to the subject.
b. Physics in medicine.
c. Applications of nuclear and particle physics to medicine.
d. Basic concepts in medical imaging.

2. Medical physics detectors and readout electronics

a. Scintillator crystals;
b. Photodetectors;
c. Gas detectors;

3. Imaging systems for ionizing radiation

a. Detection Systems for X-rays (radiography and CT).
b. Gamma cameras and single-photon emission CT (SPECT) scanners.
c. Positron emission tomography (PET) scanners.

4. Tomographic imaging

a. Transmission tomography (CT) and positron emission tomography (SPECT and PET).
b. Magnetic resonance imaging and multimodality.
c. Image degradation phenomena: Physical principles

5. Image Reconstruction

a. Data processing and format. Basic concepts of digital image
b. Image Reconstruction: Analytical methods
c. Image Reconstruction: Iterative methods (algebraic and statistical methods)
d. Compensation for image degradation phenomena
e. Image quality, evaluation and analysis-

6. Therapy based on ionizing radiation

a. Radiotherapye and brachytherapy
b. Hadron therapy

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	30,00	100
Laboratory practices	12,00	100
Other activities	4,00	100
Seminars	3,00	100
Preparing lectures	40,00	0
Preparation of practical classes and problem	61,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

MD1 - Theoretical classes, participatory master class.

MD2 – Laboratory.

MD3 – Troubleshooting.

MD4 – Problems

MD5 – Seminars.

MD6 – Visit to external scientific facilities and companies.

EVALUATION

SE1 – Written exams on theory and practical classes: based on the learning results and the specific objectives of each subject. The minimum grade for the written exam must be equal to or greater than three points out of ten. The exam mark will be used, together with the rest of the evaluable merit marks of the subject, to calculate the final mark.

SE2 – Continuous evaluation of the student in theory and practical classes (experimental and simulation): participatory assistance and exercises in the classroom.

SE3 – Continuous evaluation of the student in laboratory classes: participatory assistance, manipulation of instrumentation and equipment, organization of work, understanding and use of practice scripts, calculations, analysis of results, teamwork, etc.

SE4 – Evaluation of non-contact activities related to theory and practical classes: memories and/or practical reports delivered.

SE5 – Evaluation of non-contact activities related to laboratory classes: memories and/or reports of the delivered practices.

60% of the mark will be obtained from SE1, 20% from SE5, 10% from SE3 and the remaining 10% from SE2 and SE4.

REFERENCES

Basic

- Physics in Nuclear Medicine. S. R. Cherry. J.A. Sorenson, M. E. Phelps. Ed. Saunders.
- Techniques for Nuclear and Particle Physics Experiments. W. R. Leo. Ed. Springer.
- Radiation Detection and Measurements. G. F. Knoll. Ed. Wiley.
- The essential physics of medical imaging. J. T. Bushberg, J. A. Seibert, E. M. Leidholdt, J. M. Boone. Ed.: Lipincott, Williams & Wilkins.

Additional

- Radiation Physics for Nuclear Medicine. Eds. M. C. Cantone, C. Hoeschen. Ed.: Springer
- Medical Imaging Physics. W. R. Hendee, E. R. Ritenour. Ed.: Wiley-Liss.
- Emission Tomography: The fundamentals of PET and SPECT. Editores: M. N. Wernick. J. N. Aarsvold. Ed.: Elsevier Academic Press.
- Positron Emission Tomography: Basic Sciences. Editores: D. L. Bailey, D. W. Townsend. P. E. Valk. M. N. Maisey. Ed.: Springer.
- Medical Imaging: Signal and Systems. J. L. Prince, J. M. Links. Ed.: Pearson Prentice Hall