COURSE : **TÉCNICAS MONTE CARLO EN RADIOTERAPIA**
TRANSLATION : MONTE CARLO TECHNIQUES IN RADIOTHERAPY
NUMBER : FMD3020
CREDTIS : 10 UC / 6 SCT
MODULES : 2
FORMAT : THEORETICAL LECTURES
REQUISITES : POR DEFINIR
RESTRICTIONS : 030401, 030501, 030801, 030802, 030803
CHARACTER : OPTATIVE
QUALIFICATION : STANDARD
FORMATIVE LEVEL : DOCTORATE
DISCIPLINE : PHYSICS

I. COURSE DESCRIPTION

1.This is a practical subject that introduces the student to the use of Monte Carlo Methods for the simulation of particle transport. The student will be able to explore the use of this technique to model different sources of radiation commonly used in radiotherapy.

2.The Monte Carlo method is a statistical technique that is capable of simulating a mathematical or physical experiment by sampling with random numbers. Applied to radiotherapy, this technique explicitly simulates the transport of particles and the deposition of energy within a region of interest, allowing the calculation of dose distributions with a high degree of precision. With commercial Monte Carlo-based treatment planning systems currently available, a complete transition to Monte Carlo-based dose calculation methods is highly likely to occur over the next several years, hence the relevance of this course.

3. The course is organized in three axes. In the first axis the student knows the history and fundamental concepts of the Monte Carlo method. In the second, the focus is the use of Monte Carlo methods for simulations of the transport of particles in matter. Finally, the third axis introduces high-performance computing techniques and their application in Monte Carlo methods.

II. LEARNING OUTCOMES

At the end of the course the student will be able to:
1. Identify the fundamental concepts and formulations that are the basis of the Monte Carlo method.
2. Understand the purpose and impact of the Monte Carlo method in the field of radiotherapy, along with the limitations associated with this technique.
3. Use Monte Carlo techniques to model radiation sources commonly used in radiotherapy.
4. Improve basic knowledge of probability and statistics.
5. Execute the modeling and characterization process of a radiation equipment using Monte Carlo techniques.

III. CONTENT

Unit 1: Fundamentals of the Monte Carlo Method

1.1 introduction
- History of Monte Carlo simulations
- Monte Carlo Simulations in Medical Physics
- Monte Carlo codes currently available
- Some applications in Radiotherapy

1.2 Random variables and sampling
- Random variables
- Random numbers
- Fundamental formulation of the Monte Carlo method
- Density function sampling

1.3 Transport of particles: a simplified approach
- Boltzmann linear equation
- Introduction to the Monte Carlo method
- A Monte Carlo algorithm for the transmission of particles

1.4 Fundamentals of probability and statistics
- Expected value
- Precision and accuracy of a statistical process
- Limit theorems and their applications
- Confidence interval for a finite sample

Unit 2: Monte Carlo simulation of particle transport

2.1 Generation of random numbers
- Random number generation approaches
- Pseudo-random number generators
- Randomness tests

2.2 Variance reduction techniques
- Effectiveness of a variance reduction algorithm
- Biasing of density functions
- Splitting techniques

2.3 Geometry and particle tracking
- Discussion of a combinatorial geometry approach
- Description of edge conditions
- Particle tracking

Unit 3: Application of Monte Carlo techniques in Radiotherapy

3.1 EGSnrc code system
- Available applications
- Modeling of a detector
- Simulations of linear accelerators

IV. METHODOLOGICAL STRATEGIES

Theoretical lectures

V. EVALUATIVE STRATEGIES

Homeworks	60%
Exam	40 %

VI. BIBLIOGRAPHY

REQUIRED

- Haghighat, Alireza. Monte Carlo Methods for Particle Transport. CRC Press, 2016.
- Seco, J. and Verhaegen, F. Monte Carlo Techniques in Radiation Therapy. CRC Press, Boca Raton, FL 2013.

OPTIONAL

- Rubinstein, R. Y. Simulation and the Monte Carlo Method. Wiley-Interscience (2 edition).
- Jenkins, Theodore M., Walter R. Nelson, and Alessandro Rindi, eds. Monte Carlo transport of electrons and photons. Ettore Majorana International Science Series. 1985.
- Mayles P., Nahum A., Rosenwald J-C. Handbook of Radiotherapy Physics, Theory and Practice. CRC Press, Boca Raton, FL 2007.