Course guide
240NU216 - 240NU216 - Instrumentation

Last modified: 17/12/2023

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: MASTER'S DEGREE IN NUCLEAR ENGINEERING (Syllabus 2012). (Optional subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** English

LECTURER

Coordinating lecturer: De Blas Del Hoyo, Alfredo

Others: De Blas Del Hoyo, Alfredo
Cortes Rossell, Guillem Pere

PRIOR SKILLS

Any bachelor student of Physics or any Engineering speciality can follow this course. Some knowledge of fundamentals of nuclear physics and radiation detection will be useful, but not mandatory.

REQUIREMENTS

No previous requisites are required.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
3. Ability to use ionizing radiation detectors, appropriate to the required application, together with the associated instrumentation.
CEN5. Ability to use effectively, understand the operation and validity ranges, and interpret the results of transport calculation codes of electromagnetic radiation, charged particles and neutrons.

Generical:
1. Ability to design, calculate and design processes, equipment, facilities and plants related to the procurement of nuclear energy and the use of ionizing radiation.
2. Have adequate knowledge of mathematical aspects, analytical, scientific, instrumental, technological and management.
CGN4. Ability to conduct research, development and innovation in relation to nuclear technology.

Transversal:
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

TEACHING METHODOLOGY

1. Project-based-learning.
2. Each student (in groups) is responsible to carry out a project of nuclear instrumentation.
3. The project is divided in activities corresponding to a topic of the course.
4. Short presentations with introduction to the topics.
5. Students have information to understand the topics of the course and learn by doing the diverse steps of the project.
6. At the end of the course each group will:
a. Deliver a report with the project description,
b. Make a short presentation.

The professor introduces the basic information of the several sections.

MD.5 Project Based Learning

Throughout the course, students must design a detection system with the proper instrumentation to solve a specific problem raised at the beginning of the course.

MD.3 Scheduled independent learning

The problems suggested as experiments in the laboratory allow the students to prepare the design of the project's solution.

MD.4 Cooperative Learning

The experiments in the laboratory; the analysis of the systems proposed and the development of the solution of the project requires the complete collaboration of all the members of the working group

LEARNING OBJECTIVES OF THE SUBJECT

The main objective of the course is to provide the necessary skills to carry out detection systems for a specific application using ionizing radiation.
More specific objectives of the course are:
1. Understand the operation of radiation detectors;
2. Use of Monte Carlo methods to determine the detection efficiency, analyze the radiation transport in the detector, shielding, etc.
3. Analyze the instrumentation by using electronic circuits simulators;
4. Understand the configuration and operation of digital processing systems.
5. Design small digital circuits in a FPGA
6. Analyze the results of an experiment.

STUDY LOAD

Type	Hours	Percentage
Hours small group	40,5	36.00
Self study	72,0	64.00

Total learning time: 112.5 h

CONTENTS

Introduction

Description:
Description of the course and the project to be carried out during the course.

Related activities:
No activity

Full-or-part-time: 1h
Theory classes: 1h

Industrial nucleonic gauges

Description:
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Related activities:
A01. Design of a transmission gague.

Full-or-part-time: 2h
Theory classes: 2h

Transport simulation with Monte Carlo methods

Description:
Introduction to the use of Monte Carlo methods in nuclear instrumentation.

Specific objectives:
Introduction to FLUKA code. Use of FLUKA to simulate the detection system of the project.

Related activities:
A02. Simulation of the detection system of the project.

Full-or-part-time: 2h
Theory classes: 0h 30m
Laboratory classes: 1h 30m

Simulation of electronic circuits

Description:
Introduction to the simulation of electronic circuits. The use of a simulator is the base of the analysis and understanding of the electronic circuits used in nuclear instrumentation.

Specific objectives:
Introduction to PSpice with KiCad Electronic Design Analysis suite.

Related activities:
A03. Simulation of a biasing circuit.

Full-or-part-time: 2h
Theory classes: 0h 30m
Laboratory classes: 1h 30m

Pulse conditioning. Preamplifiers.

Description:
Analysis of the preamplfier used in the project with the simulator and testing in the laboratory.

Related activities:
A04. Analysis of preamplfiier.

Full-or-part-time: 2h
Theory classes: 0h 30m
Laboratory classes: 1h 30m

Analogic shaping of pulses. Pulse Amplifiers.

Description:
Analysis of a Gaussian filter and testing in the laboratory.

Related activities:
A06. Analysis of a Pulse Amplifier.

Full-or-part-time: 2h
Theory classes: 0h 30m
Laboratory classes: 1h 30m

Transmission of pulses in coaxial cables.

Description:
Demonstration of the effect of transmisison of fast pulses in coaxial cables. Importance of the characteristic impedance of the cable and compensation of the generator and receiver.

Related activities:
A06. Demostration of transmission of pulses in coaxial cables.

Full-or-part-time: 2h
Laboratory classes: 2h

Comparators. Single Channel Analyzer.

Description:
Analysis of a system to discriminate pulses depending on its energy. Testing in the laboratory and ajust of parameters.

Related activities:
A07. Analysis of a Single Channel Analyzer.

Full-or-part-time: 2h
Theory classes: 0h 30m
Laboratory classes: 1h 30m

Digital systems. Introduction to SoC.

Description:
Introduction to sintesis of simple digital circuits in PFGA. Development of the digital counter to be used in the project.

Related activities:
A08. FPGA. First approach: synthesis of logical gate circuits.
A09. FPGA. Counter with display.

Full-or-part-time: 4h
Theory classes: 1h
Laboratory classes: 3h

Digital filters for nuclear instrumentation.

Description:
Introduction to digital filters used in nuclear instrumentation to correct the pile up of pulses.

Related activities:
A10. Analysis of Jordanov filter. MCA.

Full-or-part-time: 2h
Theory classes: 0h 30m
Laboratory classes: 1h 30m

Measurement of small currents

Description:
Introduction to the electrometric methods to measure the current generated by ionizing radiaiton de

Full-or-part-time: 2h
Theory classes: 0h 30m
Laboratory classes: 1h 30m

Calibration and final setup of the project.

Description:
contenido castellano

Full-or-part-time: 18h
Laboratory classes: 6h
Self study : 12h

ACTIVITIES

Lectures

Description:
In the classroom, the teacher introduces the concepts in order to give to the students the capacity to develop the objectives of the subject.

Material:
The slides of the lecture will be previously submitted to the students using the virtual campus.

Full-or-part-time: 10h 15m
Theory classes: 10h 15m

Activities

Material:
The equipment of the Detection and Nuclear Instrumentation Laboratory. A guide for each session will be previously submitted to the students using the virtual campus.

Delivery:
A report for each activity is delivered.

Full-or-part-time: 6h
Laboratory classes: 6h

Project

Description:
The design of a detection system for a determined application will be developed during the course. This design will be done in groups of three students.

Delivery:
Report at the end of the trimester

Full-or-part-time: 10h
Guided activities: 10h

GRADING SYSTEM

The marks are based on the work done in the laboratory (20%), a report to be delivered (60%) and a short presentation (20%).

BIBLIOGRAPHY

Basic:
- Knoll, Glenn F. Radiation Detection and Measurement. 4th. Hoboken, New Jersey: John Wiley and Sons, 2010. ISBN 9780470131480.

Complementary:
- Jones, Brian K. Electronics for experimentation and research. Englewood Cliffs, New Jersey: Prentice/Hall International, cop 1986. ISBN 0132507544.
- Jones, Larry D; Chin, A. Foster. Electronic instruments and measurements. 2nd ed. Englewood Cliffs: Prentice-Hall, cop. 1991. ISBN 0132488574.