UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Course guide
240NU213 - 240NU213 - Core Design

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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: 2025 **ECTS Credits:** 4.5 **Languages:** English

LECTURER

Coordinating lecturer: Lluís Batet

Others: Alfredo de Blas, Raimon Pericas (UPC)

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Owning a theoretical and practical basis of reactor physics and thermal hydraulics that allow you to easily navigate issues related to plant operation and safety.
2. 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.

TEACHING METHODOLOGY

The course on Core Design is aimed at the application of the Reactor Physics to the design of a core reload. The course has been designed as face-to-face sessions where students will make use of codes, including cell codes, burn-up calculation and thermal-hydraulic coupling. As homework, students will develop models for the codes and will perform some guided analyses.

The course is divided into two related but independent parts.

The first one is devoted to the calculation of the neutron flux in the core of a nuclear reactor using a diffusion code. Sessions corresponding to this part will be distributed throughout the semester. Most of these will be face-to-face sessions.

Second part is devoted to the use of a Monte Carlo neutron transport code and its application to the determination of group constants, criticallity parameters and burn-up in cells and fuel assemblies.

LEARNING OBJECTIVES OF THE SUBJECT

Objectives. This course has the following objectives:
- Provide an overview of the phenomenon involved in the thermal power generation in a fission nuclear reactor and of the conditions that make this generation feasible.
- Provide the analytical tools needed to compute the spatial distribution and the time evolution of the power production in a fission reactor
- Present, qualitatively and quantitatively, the dynamic phenomenon affecting neutron multiplication within a reactor core, linking them with the contents of the Thermal-Hydraulics

Learning Outcomes. After following the course, students will be able to:
- Determine the reactivity of a multiplying medium knowing its composition and geometry.
- Understand, explain and apply the phenomenon that may modify the reactivity of a power nuclear reactor and the several feedback effects than can take place in it.
- Determine the timely evolution of the reactor's power level knowing the reactivity inserted and the magnitude of the feedback factors.
- Calculate the thermal power density distribution in the core of a critical reactor.
- Use in an effective way a neutron diffusion code and apply it to the solution of practical problems
- Use in an effective way a neutron transport code to determine the parameters of criticality, group constants, flux and burnup of a fuel cell or a fuel element.
- Use in an effective way a neutron transport code to generate homogenized and collapsed cross sections in a fuel cell.
- Create models of fuel assemblies for codes based on Monte Carlo methods.

STUDY LOAD

Type	Hours	Percentage
Hours large group	36,0	32.00
Self study	72,0	64.00
Hours small group	4,5	4.00

Total learning time: 112.5 h

CONTENTS

1. Application of a neutron diffusion code to core design

Description:
This part of the course is focused on the use of a neutron diffusion code and its application to the core design (i.e., what is the best strategy for core reload given certain constraints). Most of the sessions corresponding to this part, distributed through the semester, will be on hands-on, implying the direct use of the code by participants. This part will be lectured by Raimon Pericas.

Specific objectives:
At the end of this topic students should be able to:
- Read, understand and modify an input for a neutron diffusion code
- Read and extract information from the output of a neutron diffusion code calculation
- Analyze how changes in the fuel, coolant and moderator of a commercial reactor affect the reactivity and the distribution of the power density
- Explain the result of some basic operations on the reactor's reactivity and the distribution of the power density

Related activities:
This part of the course will consist on hands-on exercises using a neutron diffusion code. Part of the work (training sessions) will be carried out in the classroom. Students will then use the code out-of-classroom to complete the assignments.

Full-or-part-time: 68h
Practical classes: 16h
Self study : 52h

2. Application of a neutron transport code to reactor physics and core design

Description:
This part of the course is focused in the use of transport codes and its application to reactor physics and other related topics.

Specific objectives:
At the end of this topic the students should be able to:
- Explain the different forms of the transport equation and the methods to solve them.
- Explain the homogenization approach and the determination of cell constants.
- Explain what is the perturbation theory and how it is applied.
- Write an input card of an adequate transport code to generate the cell constants for further analysis with other codes.
- Write an input card of an adequate transport code to:
- Analyze the flux distribution in a reactor core.
- Analyze the burn up in a reactor core.
- Carry out a perturbation analysis.
- Carry out a criticality analysis.

Related activities:
Students will use deterministic and stochastic transport codes in the classroom to solve some assignments. Reading and preparation of the reports are activities to be performed out of the classroom.

Full-or-part-time: 40h
Practical classes: 20h
Self study : 20h

GRADING SYSTEM

Final qualification will be calculated taking into account the qualification of the exam of part 1 (P1E), assignments of part 1 (P1A) and equally for part 2 (P2E and P2A):

Qualification: 0,325* P1E + 0,325*P1A + 0,175*P2E + 0,175*P2A