

Environmental Protection and Power Engineering

This course provides PhD students in nuclear science and engineering with a rigorous foundation in the fundamental principles governing nuclear reactor technology. It develops both conceptual understanding and practical analytical skills essential for evaluating existing reactor systems and contributing to the design of next-generation nuclear power plants. Lectures, exercises, and case studies work together to bridge theory and practice, emphasizing efficiency, safety, and scientific rigor.

Learning objectives

After completing this course, students will be able to:

- Explain the physical principles underlying reactor physics, reactor kinetics, thermal-hydraulics, and fuel behavior.
- Describe major reactor types, their design philosophies, and their operational characteristics.
- Understand the regulatory, environmental, and safety frameworks that guide reactor design and operation.
- Apply analytical and computational methods to evaluate reactor performance.
- Perform simplified design calculations for core physics, thermal limits, and safety margins.
- Assess strengths and limitations of existing reactor technologies.
- Formulate proposals for improving reactor efficiency, safety, or sustainability.

Course contents

The following topics are included:

- Overview of nuclear technology in science and engineering
- Overview of components and systems in light water reactor (LWR) power plants
- Overview of components and systems in fast breeder reactor (FBR) power plants
- Introduction to nuclear reactor physics
- Nuclear reactor kinetics, dynamics, and stability
- Nuclear power plant operation and control
- Introduction to thermodynamics of nuclear energy systems
- Introduction to thermal-hydraulics of nuclear energy systems
- Nuclear and thermal-hydraulic design of reactor cores
- Principles of nuclear power sustainability, environmental protection, and safety

Course structure

The course is organized into short, intensive modules combining lectures, exercises, and seminars. The following time-frames for the modules are envisaged:

- Days from 9/4 to 14/4
- Days from 27/4 to 8/5
- Days from 18/5 to 29/5
- Days from 8/6 to 17/6

The first meeting will take place on April 9th at 14:00. The remaining meetings will be scheduled within the specified module time-frames at a later stage. The goal is to have all lectures, exercises, and seminars in a classroom. On-line meetings will be organized only in case when meetings in person will not be possible.

Teaching methods

- Lectures introducing theoretical foundations
- Problem-solving sessions
- Seminars where each student presents current status for a selected Gen IV or SMR reactor concept

Assessment, examination and grading

- Oral seminar presentation (30%)
- Case study report (30%)
- Final oral examination (40%)

Oral student seminars will take place during the last course module, from June 8th until June 12th. Oral exam will take place from June 15th until June 17th.

Final grading: 5, 4, 3, 2

Prerequisites

- Undergraduate-level physics, thermodynamics, fluid mechanics, solid mechanics, and heat transfer
- Familiarity with differential equations and numerical methods
- Basic programming skills (Python, MATLAB, or similar)

Course literature

Selected chapters in the following books:

H. Anglart, *Applied Reactor Technology* (PDF available)

H. Anglart, *Thermal-Hydraulics in Nuclear Systems* (PDF available)

H. Anglart, *Nuclear Reactor Dynamics and Stability* (PDF available)

H. Anglart, *Introduction to Sustainable Energy Transformation*, CRC Press, ISBN 978-0-367-47861-2

H. Anglart, *Thermal Safety Margins in Nuclear Reactors*, CRC Press, ISBN 978-1-032-17106-0