COURSE DESCRIPTION CARD - SYLLABUS

Course name
Theory of nuclear reactors [S2EJ1>TRJ]

Course

Field of study
Nuclear Power Engineering

Year/Semester
1/2

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
15

Other (e.g. online)
0

Tutorials
0

Projects/seminars
15

Number of credit points

4,00

Coordinators

dr inż. Jakub Sierchuła
jakub.sierchula@put.poznan.pl

Lecturers

Prerequisites

Mathematics: differential calculus, integral calculus. Physics: principles of conservation, heat transfer, basics of nuclear physics, basics of quantum mechanics. Programming/IT: basic knowledge of an object-oriented programming language (e.g. Python). Energy: technological systems of power plants/thermal power plants, energy balances.

Course objective

Mastering basic knowledge and skills in the field of reactor physics, neutron transport, construction and principles of operation of a nuclear reactor, and controlling the chain reaction. Learning about the basic types of nuclear reactors.

Course-related learning outcomes

Knowledge:
1. Student understands the essence of phenomena occurring in nuclear reactors.
2. Student has extended knowledge in the field of nuclear physics and reactor physics.
3. Student is able to present and describe the technological process carried out in nuclear power plants with various types of reactors.

4. Student has knowledge of the structure/principles of operation of nuclear reactors and the theory of neutron transport.

Skills:
1. Student is able to perform basic calculations of the criticality conditions of a nuclear power reactor.
2. Student is able to determine the coolant flow necessary to remove heat from the reactor core during normal operation.
3. Student, based on the given geometry and material composition, can prepare a simplified model of the reactor in neutron code.

Social competences:
1. Student is aware of the great responsibility of an energy engineer in a nuclear power plant for the decisions made.
2. Student understands the need to conduct dialogue with people skeptical about nuclear energy.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lectures
Written exam on the date given at the beginning of the semester. The list of questions is made available to students at the beginning of the semester. In doubtful cases, the exam is extended with an oral part. Students' activity is assessed during each lecture. The condition for passing the exam is to obtain at least 50% of the maximum number of points.
Laboratory classes
Continuous assessment in each class (rewarding activity). Completing classes by completing a report.
Project
Evaluation of the completed design task.

Programme content

Lectures
Nuclear fission. Fission energy. Chain reaction. Structural elements of a nuclear reactor. Materials used to build nuclear reactors. Nuclear fuel, moderator, neutron reflector. Slowing down and thermalization of neutrons. Neutron balance equations in a nuclear reactor. Power density/neutron flux distribution in the reactor. Effective neutron multiplication factor. Calculations of critical dimensions of the reactor. Neutron kinetics. Reactive effects. temperature reactivity coefficients (fuel, coolant, moderator). Nuclear reactor control. Fuel burning. Analysis of changes in isotopic composition in the core. Thermal reactors, fast neutron reactors. Overview of nuclear reactors (PWR, BWR, HTGR, CANDU, RBMK, 4th generation reactors). Thermal issues in nuclear reactor technology. Heat transfer and coolant flow. Basics of radiological protection (radiation shields).
Laboratory classes
Modeling of phenomena occurring in nuclear reactors using the stochastic OpenMC neutron code. Preparation of a nuclear reactor model. Preparation of a nuclear reactor model. Determination of the effective neutron multiplication factor. Analysis of selected parameters/core geometry on neutron kinetics. Calculations of temperature reactivity coefficients. Determination of the neutron spectrum. carrying out burn-in calculations. Analysis of the isotopic composition of the fuel.
Project
Designing a nuclear reactor of a selected generation.

Course topics

none

Teaching methods

Lectures
Lecture with a multimedia presentation supplemented with examples given on the blackboard or generated using specialized computational tools.
Laboratory classes
Classes carried out on computers with the OpenMC stochastic neutron code
Project

Classes carried out on computers with the stochastic neutron code OpenMC

Bibliography

Basic:
1. Glasstone S., Edlund M.C., Podstawy Teorii Reaktorów Jądrowych, Państwowe Wydawnictwo Naukowe, Warszawa 1957
2. Glasstone S., Podstawy Techniki Reaktorów Jądrowych, Państwowe Wydawnictwo Naukowe, Warszawa 1958
3. Kiełkiewicz M., Teoria Reaktorów Jądrowych, Państwowe Wydawnictwo Naukowe, Warszawa 1987
4. Dobrzyński L., Zarys Nukleoniki, Polskie Wydawnictwo Naukowe, Otwock 2017
5. Celiński Z., Strupczewski A., Podstawy Energetyki Jądrowej, Wydawnictwo Naukowo Techniczne, Warszawa 1984

Additional:
1. Kiełkiewicz M., Podstawy fizyki reaktorów jądrowych. Cz. 1, Wydawnictwa Politechniki Warszawskiej, Warszawa 1977
2. Kiełkiewicz M., Podstawy fizyki reaktorów jądrowych. Cz. 2, Wydawnictwa Politechniki Warszawskiej, Warszawa 1980
3. Masterson R.E., Introduction to Nuclear Reactor Physics, CRC Press, 2017

Breakdown of average student's workload

	Hours	ECTS
Total workload	107	4,00
Classes requiring direct contact with the teacher	62	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	45	1,50