# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Safety of nuclear power plants [S2EJ1>BEJ]

## 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
elective

## Number of hours

Lecture
30

Laboratory classes
0

Other
0

Tutorials
15

Projects/seminars
15

## Number of credit points

4,00

## Coordinators

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## Lecturers

## Prerequisites

Mathematics: algebraic functions, equations and systems of equations, basics of probability calculus, basics of differential and integral calculus at PRK 6 level, solving algebraic equations and systems of equations, solving simple differential equations, using integral calculus to calculate geometric and physical quantities. Physics: principles of conservation in physics, statics, kinematics, dynamics, hydrodynamics, heat transfer at PRK level 6, basics of reactor physics, solving problems in classical mechanics, statics, dynamics and mechanics of fluids and heat transfer.

## Course objective

Acquiring knowledge and skills in the field of Nuclear Power Plants (NPP) safety, construction and operation of nuclear power plant safety systems, impact of nuclear power plants on the environment, methods of assessing risks related to the operation of nuclear power plants.

## Course-related learning outcomes

Knowledge:
1. The student knows the safety rules used in nuclear energy.
2. The student knows the structure and understands the operation of nuclear power plant safety

systems.
3. The student has knowledge of the potential impact of a nuclear power plant on the environment in emergency situations.
4. The student knows the barriers that prevent radioactive substances from entering the environment.
5. The student knows the International Nuclear Emergency Scale (INES) and understands its application.
6. The student has knowledge of the methodology for calculating the reliability of technical systems, knows the basic reliability structures and understands their properties.
7. The student knows and understands the physical basis of operation of passive NPP security systems.
8. The student knows the probabilistic risk assessment (PRA) methodology and its application to assess the safety of nuclear power plants.

Skills:
1. The student is able to estimate the reliability of a simple NPP safety system using the "event trees" or "fault trees" methodology.
2. The student is able to calculate the coolant flow necessary for emergency cooling of the NPP core.
3. The student is able to calculate, using simplified methods, the flow characteristics of emergency cooling systems for the NPP core.
4. The student is able to determine temperature distributions in nuclear fuel during normal operation and in emergency situations.
5. The student is able to calculate the reliability of a complex technical structure and indicate ways to improve reliability.

Social competences:
1. The student understands the need for teamwork in solving theoretical and practical problems of nuclear energy.
2. The student understands the need to systematically deepen and expand his knowledge and skills.
3. The student is aware of the need for social dialogue on matters related to the impact of nuclear energy on the environment

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lectures
40-minute written assessment during the last class of the semester. The assessment is intended to test the student's knowledge and involves answering 4 questions. The list of questions is made available to students at the beginning of the semester. In doubtful cases, the assessment is extended to include an oral part. Students' activity is assessed during each lecture.
Exercise auditorium
Continuous assessment in each class (rewarding activity). A 60-minute written final test at the end of the semester. The colloquium aims to test students skills and involves solving two tasks.
Design
Phased assessment of the implementation of key project points. Assessment of the presentation and defense of the entire project.
The condition for obtaining credits for lectures and tutorials exercises is to obtain at least 50% of the maximum number of points of 20. Grading scale: 0-9 points = 2.0; 10-12 points = 3.0; 13-14 points = 3.5; 15-16 points = 4.0; 17-18 points = 4.5; 19-20 points = 5.0.
The condition for passing the project is its submission in electronic version and positive defense.

## Programme content

The module program covers the following topics:
1. safety strategy in nuclear energy,
2. generations of nuclear power plants and their safety,
3. safety systems of nuclear power plants (active and passive),
4. barriers in the way of radioactive substances to the environment,
5. the impact of a nuclear power plant on the environment during normal operation,
6. safety zones around the nuclear power plant,
7. threats in emergency situations,
8. comparison of the threat from the nuclear power plant with other civilization threats.

## Course topics

The lecture program covers the following topics:
1. classification of possible failures,
2. International Nuclear Emergency Scale (INES),
3. maximum hypothetical accident (MHA),
4. maximum design accident (MPA),
5. LOCA type failure,
6. decay heat,
7. decay heat removing in emergency situations,
8. emergency reactor shutdown systems,
9. emergency core cooling systems,
10. containment enclosure and its systems,
11. measures of reliability of technical systems,
12. reliability structures and their properties,
13. basics of the PRA methodology, event trees and fault trees.

The tutorials covers the following topics:
1. thermal and flow calculations of emergency core cooling systems,
2. analysis of the operation of containment systems (spraying, ventilation, hydrogen recombination),
3. calculating the probabilities of exemplary failure chains,
4. calculating the temperature distribution in nuclear fuel,
5. calculation of pressure and temperature changes in the containment in emergency situations.

The design exercise program covers the following topics:
1. high-pressure emergency core cooling system,
2. emergency sprinkler system for the interior of the containment enclosure,
3. emergency containment ventilation system,
4. passive system for long-term decay heat removing.

## Teaching methods

Lectures: multimedia presentation (including drawings, photos, animations) supplemented with explanations provided on the blackboard.
Auditorium exercises: solving sample tasks using educational computer software and own programs, initiating discussions on the consequences of the simplifications used and the accuracy of the obtained calculation results.
Project: team work of students on the design of a selected NPP emergency system carried out under the supervision of the instructor.

## Bibliography

Basic:
1. Strupczewski A., Awarie reaktorowe, WNT, W-wa 1990.
2. Hrynkiewicz Z. (Red.): Człowiek i promieniowanie jonizujące. PWN, W-wa, 2001.
3. Dobrzyński L. (Red.): Zarys nukleoniki. PWN, W-wa 2017.
4. Ablewicz Z., Dąbrowski W.B. Osłony przed promieniowaniem jonizującym. Arkady, W-wa 1986.
5. Kiełkiewicz M. Jądrowe reaktory energetyczne. WNT, W-wa 1978.
6. Masterson R.E., Nuclear Reactor Thermal Hydraulics. An introduction to Nuclear Heat Transfer and Fluid Flow, CRC Press, 2019.

Additional:
1. Petrangeli G.: Nuclear Safety. 1st Ed. Butterworth-Heinemann, 2006
2. Elkmann P.: Emergency Planning for Nuclear Power Plants. CRC Press, 2009
3. Murray R.L., Nuclear Energy (6th Ed.), Elsevier, Amsterdam 2009.

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 110 | 4,00 |
| Classes requiring direct contact with the teacher | 60 | 2,00 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 50 | 2,00 |