SYLLABUS

1. Data about the program of study

1.1	Institution	Technical University of Cluj-Napoca
1.2	Faculty	Faculty of Electrical Engineering
1.3	Department	Power Systems and Management
1.4	Field of study	Energy Engineering
1.5	Cycle of study	Master of Science
1.6	Program of study/ Qualification	Modern power systems - Cluj-Napoca in English language
1.7	Form of education	Full time

2. Data about the subject

2.1	Subject name			Fundamentals of nuclear theory	
2.2	Course responsible/ lecturer			Prof. dr. Ioan ARDELEAN; ioan.ardelean@phys.utcluj.ro	
2.3	Teachers in charge of Seminars/ Laboratory/ Project			Prof. dr. Ioan ARDELEAN; ioan.ardelean@phys.utcluj.ro	
2.4 Year of study	1	2.5 Semester	1	2.6 Type of assessment *(E – exam, C – colloquium, V – verification)*	E
2.7 Subject category	*DF – fundamental, DD – in the field, DS – specialty, DC – complementary*				DF
	DI – compulsory, DO – elective, Dfac – optional				DI

3. Estimated total time

3.1 Number of hours per week:	3	of which	3.2 Course	2	3.3 Seminar		3.3 Laboratory	1	3.3 Project	
3.2 Total hours per semester	42	of which	3.5 Course	28	3.6 Seminar		3.6 Laboratory	14	3.6 Project	

3.7 Individual study:	
(a) Manual, lecture material and notes, bibliography	24
(b) Supplementary study in the library, online and in the field	14
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays	14
(d) Tutoring	2
(e) Exams and tests	4
(f) Other activities	

3.8 Total hours of individual study *[sum (3.7(a) to 3.7(f))]*	58
3.9 Total hours per semester *[sum of 3.4 and 3.8]*	100
3.10 Number of credit points	4

4. Prerequisites (where applicable)

4.1	Curriculum	- graduation of a general physics course containing notions of electricity, magnetism and quantum physics
4.2	Competences	- to be able to operate with notions related to electric forces, magnetic forces, energies of electrically charged particle systems;

5. Requirements (where appropriate)

5.1	For the course	Video proiector / online (Teams)

5.2	For the applications	Mandatory presence at the laboratory according to the UTCN regulation.

6. Specific competences

Professional competences	After completing the course, students will accumulate knowledge in nuclear physics being able to: - to describe the structure of the atom, identifying the mass and charge of each elementary particle that goes into its composition; excitation/de-excitation of the nucleus based on the model of energy levels; - explain the stability of nuclei based on the properties of nuclear forces; - to state the law of radioactive decay, to define the types of radioactive decays; - define the activity of a radioactive source and the half-life. - to know the main types of reactors and to be able to present the operating principle of a CANDU reactor.
Cross competences	- Responsible execution of professional tasks in conditions of restricted autonomy (realization of homework for independent study); - Awareness of the need for continuous training; effective use of learning resources and techniques, for personal and professional development - efficient use of communication and training resources (Internet, databases, etc.), including using foreign languages.

7. Expected learning outcomes

Knowledge	Understand the structure and properties of atomic nuclei and nuclear forces. Explain the mechanisms of radioactive decay and nuclear reactions. Describe the principles of operation of nuclear reactors and particle accelerators. Understand the interaction of nuclear radiation with matter and the principles of radiation detection.
Skills	Calculate radioactive decay parameters, activity, half-life and released nuclear energy. Analyze nuclear processes using conservation laws and basic nuclear models. Use experimental methods and software tools for the analysis of nuclear physics data. Interpret experimental results related to radiation attenuation, NMR measurements and nuclear detection techniques.
Responsibility and autonomy	Perform laboratory activities responsibly and in compliance with safety regulations. Independently solve problems related to nuclear physics and nuclear engineering. Use scientific documentation and online resources for continuous professional development. Communicate scientific results clearly and correctly in written and oral form.

8. Discipline objectives (based on specific competencies acquired)

7.1	General objective	Acquisition of knowledge of nuclear physics in order to obtain competence in the field of nuclear engineering.
7.2	Specific objectives	• Knowledge of the structure of the atom and the nucleus; its stability • Know the types of radioactive decays.

		• Describe the process of nuclear fission and fusion and identify fission products. • To know the working principle of a neutron moderator. • Know the main types of accelerators. • Know the main techniques for detecting radiation.

9. Contents

9.1. Course (Lectures)		Number of hours	Teaching methods	Additional remarks
1	Introduction. Evolution of ideas in atomic and nuclear physics. Romanian contributions.	2	Systematic exposure, conversation, theoretical and experimental demonstration, observation. Problematization, shaping, case study, Learning by discovery	
2	The atomic nucleus. Structure of the nucleus. Nuclear forces. The nuclear potential pit. Core stability.	2		
3	Natural and artificial radioactivity. Radiation sources. Radioactive series.	2		
4	The law of radioactive decay. The activity of a source. Half-life. Average lifespan. Dating with ^{14}C.	2		
5	Types of nuclear decays. Alpha disintegration. Beta disintegration. Internal conversion. Gamma emission. Spontaneous fission.	2		
6	Interaction of radiation with the substance. Radiation attenuation. Effects of irradiation on the substance. Radiation dosimetry.	2		
7	Nuclear radiation detectors. Fog room. Bubble room. Geiger-Muller counter. Semiconductor detectors.	2		
8	Nuclear reactions. Conservation laws. Types of neutron reactions.	2		
9	Effective section in nuclear reactions. Neutron flux.	2		
10	Nuclear fission. The energy released. Fission products. Chain fission and multiplication coefficient.	2		
11	Particle accelerators. Linear accelerator. The cyclotron. The synchrotron. Betatron.	2		
12	Reactorul nuclear. Componentele esențiale. Tipuri de reactori.	2		
13	The CANDU reactor. The principle of operation.	2		
14	Nuclear fusion and the potential impact on energy production.	2		

Bibliography

1. I. Ardelean, Fundamentals of nuclear physics-lecture notes (PDF file, RO)
2. Prof. Dr. Grigore Damin, UBB, Note de curs Online, (Curs de Fizica Nucleara)
http://www.phys.ubbcluj.ro/~grigore.damian/lectures.html.
2. I. Ardelean, Introducere in mecanica cuantica, Editura U.T.Press, Cluj-Napoca, 2002, ISBN 973-8335-24-8(199 p)

4. H. D. Young, R. A. Freedman - Sears and Zemansky's University Physics with Modern Physics Technology Update (lb. engleza), Pearson – 2013
5. http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
6. Prof. Markus Klute, MIT, USA, Introduction to nuclear and particle physics, Note de curs online https://ocw.mit.edu/courses/8-701-introduction-to-nuclear-and-particle-physics-fall-2020/

9.2. Applications - Seminar /Laboratory/Project		Number of hours	Teaching methods	Additional remarks
1	Introduction. Labor protection. List of works. Calculation of errors. Graphical representation and data analysis in Origin.	2	Theoretical and experimental demonstration, conversation, observation and analysis	
2	Mass defect and equivalent energy: the study by numerical simulations.	2		
3	Study of the absorption of beta radiation in aluminum.	2		
4	Study of Attenuation of Gamma Radiation in Lead and Iron.	2		
5	Spectral analysis of radiant sources of electromagnetic energy.	2		
6	Detection of proton spin by nuclear magnetic resonance.	2		
7	Determination of the relaxation time of the proton spin in liquids. The analogy with nuclear decay.	2		

Bibliography
1. Prof. Markus Klute, MIT, USA, Introduction to nuclear and particle physics, Note de curs online https://ocw.mit.edu/courses/8-701-introduction-to-nuclear-and-particle-physics-fall-2020/
2. Prof. Dr. Grigore Damin, UBB, Note de curs Online, (Curs de Fizica Nucleara) http://www.phys.ubbcluj.ro/~grigore.damian/lectures.html.
3. T. I. Crețu, Fizica-curs universitar, Ed. Tehnica, București, 1996

10. Alignment of course content with expectations of the epistemic community, professional associations, and representative employers in the field

The content of the discipline and the skills acquired correspond to the expectations of the professional organizations and companies in the field where students carry out internships and/or take up a job, as well as the national quality assurance bodies (ARACIS)

11. Assessment

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade (%)
10.4 Course	The completeness and correctness of the accumulated knowledge, the logical coherence and the ability to operate with the assimilated knowledge in complex intellectual activities.	Summative assessment – final exam	60%

10.5 Laboratory	The ability to apply in practice, in different contexts, the accumulated knowledge;	Formative assessment along the semester. Presentation of papers on specific topics and discussions.	40%
10.6 Minimum standard of performance: nota 5			

Date of completion	Lecturers	Title/ Surname/ Name:	Signature
September 2025	Course	Prof. dr. Ioan ARDELEAN	
	Applications Seminar/ Laboratory/ Project	Prof. dr. Ioan ARDELEAN	

Date of approval in the council of the Department of Power Engineering and Management

September 2025

Head of Department:
Assoc. Prof. Eng. Horia G. BELEIU, PhD

Date of approval in the Faculty of Electrical Engineering Council

September 2025

Dean:
Assoc. Prof. Eng. Andrei C. CZIKER, PhD