

**MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE  
VASYL STEFANYK PRECARPATHIAN NATIONAL UNIVERSITY**



**Co-funded by  
the European Union**



Faculty of Physics and Technology  
Department of Materials Science and New Technologies

**SYLLABUS OF THE TRAINING COURSE**

**Radiation Safety: European-Ukrainian Approach**

Ivano-Frankivsk – 2023

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## 1. General information

Name of the course	Radiation Safety: European-Ukrainian Approach
Educational program	EP “Physics and Astronomy”, “Applied Physics and Nanomaterials”, “Physical Materials Science” (Faculty of Physics and Technology, PNU), EP “Law”, “International Law” (Juridical Institute, PNU), EP “Medicine”, “Pharmacy” (IFNMU)
Specialization (if any)	–
Specialty	“Physics and Astronomy”, “Applied Physics and Nanomaterials”, “Materials Science”, “Law”, “Medicine”, “Pharmacy, Industrial Pharmacy”
Field of knowledge	10 Natural Sciences 13 Mechanical Engineering 08 Law 22 Healthcare
Educational level	bachelor, master
Course status	elective
Year / semester	arbitrary distribution
Distribution by types of classes and hours of study (if other types are provided, add)	Lectures – 30 hours Practical classes – 24 hours
Language of teaching	English
Link to the distance learning site	<a href="https://d-learn.pnu.edu.ua/developer/course/subscribes/7048">https://d-learn.pnu.edu.ua/developer/course/subscribes/7048</a>

## 2. Course description

### Purpose and objectives of the course

The purpose of the educational module is to develop a positive, scientifically grounded attitude towards nuclear energy among students, postgraduates, teachers, and indirectly among the civically active part of society, based on current European positions, provided the dissemination of knowledge and experience in the field of radiation safety.

### Competences

- **Instrumental competences:** ability to analyse and synthesize; ability to organize activities and manage time; basic general knowledge; ability to use knowledge in practice; information management skills (the ability to find and analyse information from various sources); problem solving.
- **Interpersonal competences:** the ability to criticize; self-criticism; interaction (teamwork); interpersonal skills and abilities; ability to work in an interdisciplinary team; ability to communicate with experts from other fields; ability to work in an international environment; ethical obligations.
- **System competences:** research skills and abilities; ability to learn; ability to generate new ideas (creativity); leadership skills; ability to work independently; planning and management of projects; environmental care.

### Program learning outcomes

The expected result of the multidisciplinary nature (physics/engineering-biology/medicine-law/mechanisms of social regulation) of the planned educational activities among students and educational institutions of Ukraine (PNU, IFNMU) and Poland (AGH UST) aim to cultivate competences among the socially active population. These competences are fundamentally necessary for adapting public consciousness to the European Commission's ideas on the controlled use of atomic energy. This adaptation necessitates awareness and scientifically informed control of all risk factors, along with strict adherence to the radiation safety measures stipulated by European legislation and regulatory acts.

The breadth of the expected target audience of the project will ensure that the module will not only perform an educational function, but will, in the medium term, contribute to the policy of the European Commission in supporting the idea of “reasonable and controlled use of nuclear energy.”

- ✓ Expanding employment opportunities and improving the career prospects for graduates by strengthening the European dimension in educational programs; raising awareness of the regulatory framework of the European Union in the critically necessary area of energy security, awareness of the need for reforms in the industry with the opportunity to actively participate in them, and the formation of a pro-European civic position.
- ✓ Expansion of professional competences, the opportunity to participate in an interesting field at the intersection of natural and social sciences, while disseminating global and European values that are critical for accession of Ukraine to the European Union. The work within the framework of the course preparation is expected to become the basis for the development of scientific and methodological cooperation between universities within Ukraine and within Eastern Europe.
- ✓ Raising awareness of nuclear energy as a necessary means of achieving energy security in the presence of manageable risk factors, minimization of which involves compliance with radiation safety standards while implementing EU regulations and policy principles.

### 3. Course structure

No.	Topic	Learning outcomes	Tasks
1.	Physical nature and sources of ionizing radiation. The composition of the atomic nucleus. Characteristics of the nuclei. Isotopes and isobars. Radioactivity, radioactive radiation. Radioactive decay law. The main patterns of alpha and beta decays, gamma radiation of nuclei. Physical bases of interaction of ionizing radiation with matter: energy transfer, ionization. Linear energy transfer. Interaction of alpha particles with matter. Interaction of beta particles with matter. Passage of gamma quanta through matter. Interaction of neutrons with matter. Principles of registration of charged particles and gamma quanta.	Raising awareness of nuclear energy as a necessary means of achieving energy security in the presence of manageable risk factors, the minimization of which involves compliance with radiation safety standards in the implementation of EU regulations and policy principles.	<ul style="list-style-type: none"> <li>• Tasks for individual work</li> <li>• Tasks for practical classes</li> <li>• Tasks for independent work</li> <li>• Test questions</li> </ul>
2	Man-made radioactive sources. Sources of beta, alpha, gamma, and X-ray radiation; isotopic neutron sources; closed sources; open sources and isotope generators; general principles for the safety of radiation sources; production of radioisotopes. Nuclear weapons. Damage factors. Radioactive fallout. Nuclear reactors: a review of nuclear fission and thermonuclear fusion reactions; neutroneceleration; neutrons, multiplication factor, criticality; the main elements of a nuclear reactor; types of reactors; experimental reactors; nuclear fuel cycle facilities. Radiation sources in the reactor core and in the heat exchange system. NPP emissions into the atmosphere. Materials for protection against neutron radiation. Radiation generators. Generation of charged particles: linear accelerators; betatrons; cyclotrons. X-ray generation: low-energy X-ray facilities; linear accelerators; other	Raising awareness of nuclear energy as a necessary means of achieving energy security in the presence of manageable risk factors, the minimization of which involves compliance with radiation safety standards in the implementation of EU regulations and policy principles.	<ul style="list-style-type: none"> <li>• Tasks for individual work</li> <li>• Tasks for practical classes</li> <li>• Tasks for independent work</li> <li>• Test questions</li> </ul>

	<p>facilities; principles and spectra; filtering and beam quality. Neutron generation: (d, n) and (p, n) reactions; generation of neutrons for neutron therapy. The use of ionizing radiation in medicine, industry, and agriculture.</p>		
3	<p>Basics of spaceflight radiation safety. Radiation conditions in outer space. Galactic and solar cosmic rays. Radiation belts of the Earth. Features of radiation protection in space. Space flight radiation safety standards. Ensuring radiation safety in aviation and space flights. Detection of radioactive radiation. Activity and its units. Specific, specific volume and specific surface activity. Basic, normalized, and operational quantities of radiation safety. Exposure, absorbed, equivalent and effective dose of radiation. Dose rate. Individual and collective exposure dose, expected exposure doses. Dosimetric quantities of exposure (power); kerma (power); transferred energy; absorbed dose (power); linear energy transmission (LET); linear energy; dose per organ. Radiation protection quantities. Equivalent dose (power); radiation weighting factor (<math>w_R</math>); effective dose; tissue weighting factor (<math>w_T</math>); operational quantities: ambient dose equivalent; directional dose equivalent; personal dose equivalent; expected dose. Devices for radiometric and dosimetric control. Gas-filled detectors. Ionization chambers with current measurements; integrating chambers; high pressure ionization chamber; extrapolation chambers; proportional chambers. Geiger-Mueller counters; scintillation detectors; solid and liquid scintillators; semiconductor detectors; photographic emulsions. Thermoluminescent detectors. Nuclear track detectors. Neutron</p>	<p>Raising awareness of nuclear energy as a necessary means of achieving energy security in the presence of manageable risk factors, the minimization of which involves compliance with radiation safety standards in the implementation of EU regulations and policy principles.</p>	<ul style="list-style-type: none"> <li>• Tasks for individual work</li> <li>• Tasks for practical classes</li> <li>• Tasks for independent work</li> <li>• Test questions</li> </ul>

	<p>detectors. Detectors utilizing (n, <math>\gamma</math>) or (n, p) reactions, activation. Detectors with imaging.</p> <p>The level of the natural radiation background. The problem of radon. Technologically altered radiation background.</p>		
4	<p>Fundamentals of radiation biochemistry. Breaking of chemical bonds through excitation ionization; direct and indirect influence of radiation: formation of free radicals, interaction with DNA; interaction with proteins and lipids.</p> <p>Effects of radiation on cells, chromosomes, DNA. Point mutations, chromosome breaks, mitosis; mitotic dysfunction, cell death; consequences of cell death; consequences of cell damage; DNA repair; cell sensitivity. Radiosensitizers and protective factors. Chromosomal aberrations as a biological indicator of dosage. Effects of total body irradiation. Overall dose-response curve; threshold; heaviness; acute radiation syndrome (ARS); hematopoietic system; gastrointestinal tract; central nervous system. Effects of partial irradiation of the body. Skin; thyroid gland, lungs, lens of the eye; gonads. Threshold doses; fractionation and dose rate effects.</p>	<p>Expansion of professional competences, the opportunity to participate in an interesting field at the intersection of natural and social sciences, while disseminating global and European values that are critical for accession of Ukraine to the European Union. The work within the framework of the course preparation is expected to become the basis for the development of scientific and methodological cooperation between universities within Ukraine and within Eastern Europe.</p>	<ul style="list-style-type: none"> <li>• Tasks for individual work</li> <li>• Tasks for practical classes</li> <li>• Tasks for independent work</li> <li>• Test questions</li> </ul>
5	<p>Elementary genetics; natural mutations; gamete formation and chromosome damage (examples); gene mutations; data sources: humans and animals; double dose concept; the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the approach of the International Commission on Radiological Protection (ICRP); ICRS risk tolerances: impact on next generations.</p> <p>Radiation effects. Sensitivity at different stages of development; brain development and</p>	<p>Expansion of professional competences, the opportunity to participate in an interesting field at the intersection of natural and social sciences, while disseminating global and European values that are critical for accession of Ukraine to the European Union. The work within the framework of the course preparation is expected to become the basis for the development of scientific and methodological</p>	<ul style="list-style-type: none"> <li>• Tasks for individual work</li> <li>• Tasks for practical classes</li> <li>• Tasks for independent work</li> <li>• Test questions</li> </ul>

	developmental delay; induction of leukaemia and cancer. Epidemiological studies. Statistical requirements; modern types of research; association and mixing coefficients; power and accuracy; prospects and pitfalls. Radiation damage. Necessity for cumulative damage. Effective dose; dose limits; the concept of collective dose; approach adopted by the ICRP; comparison of risks from different types of activities.	cooperation between universities within Ukraine and within Eastern Europe.	
6	Legal regulation of relations in the field of nuclear and radiation safety in Ukraine and the EU: a comparative analysis. National legislation of Ukraine (Laws of Ukraine "On the use of atomic energy and radiation safety", "On licensing activities in the field of the use of atomic energy", "On the physical protection of nuclear installations, nuclear materials, radioactive waste, other sources of ionizing radiation", "On handling with radioactive waste", etc.). Safety requirements and the regulatory framework of the EU. EU regulators. The process of harmonization of the legislation of Ukraine and the EU in the field of regulation of the use of nuclear energy and radiation safety.	Expanding employment opportunities and improving the career prospects for graduates by strengthening the European dimension in educational programs; raising awareness of the regulatory framework of the European Union in the critically necessary area of energy security, awareness of the need for reforms in the industry with the opportunity to actively participate in them, and the formation of a pro-European civic position.	<ul style="list-style-type: none"> <li>• Tasks for individual work</li> <li>• Tasks for practical classes</li> <li>• Tasks for independent work</li> <li>• Test questions</li> </ul>
7	Means of state regulation of safety in the use of nuclear energy: registration, standardization, certification, licensing, control over radiation sources, including criteria for storage and disposal of waste; withdrawal; release from control. Licensing of the use of nuclear energy: obligations of licensees, registrants, and employers; relationship between the regulator and regulated institutions; national inventory of radiation sources; import, export, transport. Safety assessment; compliance with safety requirements; application of sanctions.	Expanding employment opportunities and improving the career prospects for graduates by strengthening the European dimension in educational programs; raising awareness of the regulatory framework of the European Union in the critically necessary area of energy security, awareness of the need for reforms in the industry with the opportunity to actively participate in them, and the formation of a pro-European civic position.	<ul style="list-style-type: none"> <li>• Tasks for individual work</li> <li>• Tasks for practical classes</li> <li>• Tasks for independent work</li> <li>• Test questions</li> </ul>



	Requirements for staff training. Licensing of activities of personnel and officials of the operating organization. Legal mechanism for preventing and avoiding emergencies at nuclear facilities. Legal mechanism for compensation for nuclear damage. Dissemination of information on the protection and safety of nuclear installations.		
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#### 4. Course evaluation system

Accumulation of points during course study	
Types of educational work	Maximum number of points
Lecture	sufficient/insufficient
Practical training	sufficient/insufficient
Laboratory classes	
Independent work	sufficient/insufficient
Individual task	sufficient/insufficient
Exam	
Maximum number of points	sufficient/insufficient

*Evaluation criteria on a 100-point scale:*

- *50-100 points*– The student is fluent in the educational material; expresses his/her thoughts; creatively performs individual and collective tasks; independently finds additional information and uses it to implement the tasks set before him/her; freely uses new information technologies to supplement own knowledge; can reasonably choose a rational way of performing the task and evaluate the results of his/her own practical activity; performs tasks not provided for by the curriculum; freely uses knowledge to solve the tasks assigned to him/her; the student's communication skills and abilities are developed at a high level.
- *0-50 points*– The student has not developed communication skills; the student makes a large number of grammatical errors, which makes understanding difficult; does not know the educational material; performs only basic tasks and requires constant assistance from a teacher.

## 5. Resource support

Material and technical support	Multimedia (video files, electronic visualization resources)
Literature:	
<a href="https://www.nuclear-power.com/nuclear-engineering/radiation-protection/">https://www.nuclear-power.com/nuclear-engineering/radiation-protection/</a> <a href="https://huri.harvard.edu/news/mapa-advances-research-chornobyl-chernobyl-nuclear-disaster">https://huri.harvard.edu/news/mapa-advances-research-chornobyl-chernobyl-nuclear-disaster</a> <a href="https://www.world-nuclear.org/sustainable-development-goals-and-nuclear.aspx">https://www.world-nuclear.org/sustainable-development-goals-and-nuclear.aspx</a> <a href="https://uen.pressbooks.pub/introductorychemistry/chapter/biological-effects-of-radiation/">https://uen.pressbooks.pub/introductorychemistry/chapter/biological-effects-of-radiation/</a> <a href="https://www.env.go.jp/en/chemi/rhm/basic-info/index.html">https://www.env.go.jp/en/chemi/rhm/basic-info/index.html</a> <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4060780/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4060780/</a> <a href="https://www-pub.iaea.org/MTCD/Publications/PDF/TCS-42_web.pdf">https://www-pub.iaea.org/MTCD/Publications/PDF/TCS-42_web.pdf</a> <a href="https://www.unscear.org/unscear/en/publications/radiation-effects-and-sources.html">https://www.unscear.org/unscear/en/publications/radiation-effects-and-sources.html</a> <a href="https://www.icrp.org/page.asp?id=10">https://www.icrp.org/page.asp?id=10</a> <a href="https://kosatka.media/en/category/blog/news/samye-masshtabnye-radiacionnye-avarii-mira">https://kosatka.media/en/category/blog/news/samye-masshtabnye-radiacionnye-avarii-mira</a> <a href="https://www.irpa.net/page.asp?id=54604">https://www.irpa.net/page.asp?id=54604</a>	

## 6. Contact information

Department	<a href="https://kmint.pnu.edu.ua/en/">https://kmint.pnu.edu.ua/en/</a>
Teacher	<b>Volodymyr Kotsiubynskyi</b> Doctor of Physical and Mathematical Sciences, Professor <b>Volodymyra Boichuk</b> Doctor of Physical and Mathematical Sciences, Professor <b>Nadiia Kobetska</b> Doctor of Juridical Sciences, Professor <b>Liliia Turovska</b> Candidate of Chemical Sciences, Associate Professor <b>Taras Parashchuk</b> Candidate of Physical and Mathematical Sciences
Contact details of the teacher	<a href="mailto:volodymyr.kotsiubynsky@pnu.edu.ua">volodymyr.kotsiubynsky@pnu.edu.ua</a> <a href="mailto:volodymyra.boichuk@pnu.edu.ua">volodymyra.boichuk@pnu.edu.ua</a> <a href="mailto:nadiia.kobetska@pnu.edu.ua">nadiia.kobetska@pnu.edu.ua</a> <a href="mailto:lilia.turovska@pnu.edu.ua">lilia.turovska@pnu.edu.ua</a> <a href="mailto:parashchuk@agh.edu.pl">parashchuk@agh.edu.pl</a>

## 7. Course policy

Academic integrity	<p>Compliance with academic integrity is based on a number of provisions and principles of academic integrity that regulate the activities of higher education applicants (students) and university teachers:</p> <ul style="list-style-type: none"> <li>➤ <a href="#">Code of Honour of Vasyl Stefanyk Precarpathian National University, Order No. 530 of 27.09.2022 "On the introduction of a new version of the Code of Honour of Vasyl Stefanyk Precarpathian National University";</a></li> <li>➤ <a href="#">Regulations on the Prevention of Academic Plagiarism and Other Violations of Academic Integrity in the Educational and Research Work of Students of Vasyl Stefanyk Precarpathian National University;</a></li> <li>➤ <a href="#">Regulations on the Commission on Ethics and Academic Integrity of Vasyl Stefanyk Precarpathian National University;</a></li> <li>➤ <a href="#">Regulations on the Prevention of Academic Plagiarism at Vasyl Stefanyk Precarpathian National University;</a></li> <li>➤ <a href="#">Members of the Commission on Ethics and Academic Integrity of Vasyl Stefanyk Precarpathian National University;</a></li> <li>➤ <a href="#">Letter of the Ministry of Education and Science of Ukraine "On the issue of avoiding problems and mistakes in the practices of ensuring academic integrity".</a></li> </ul> <p>These regulations and documents are available at the following link:<a href="https://pnu.edu.ua/polozhennia-pro-zapobihannia-plahiatu/">https://pnu.edu.ua/polozhennia-pro-zapobihannia-plahiatu/</a></p>
Inappropriate behaviour during class	<p>Inappropriate behaviour during classes is regulated by a number of provisions on academic integrity (see above) and may lead to the expulsion of a higher education applicant (student) "for violation of the academic discipline and internal regulations of a higher education institution", in accordance with clause 14 "Expulsion of students" of the "Regulations on the procedure for transfer, expulsion, and re-enrolment of students of higher education institutions" - the regulation is available at the following link: <a href="https://nmv.pnu.edu.ua/нормативні документи/polozhenja/">https://nmv.pnu.edu.ua/нормативні документи/polozhenja/</a></p>
Extra points	<p>Receiving extra points in the course is possible in case of completion of individual assignments previously agreed with the teacher. The list of individual assignments is contained in the course curriculum. Also, by the decision of the department, students who have participated in research work (conferences, student research clubs and problem groups, preparation of publications), as well as participants in competitions, may be awarded extra points in accordance with the Procedure for Organising and Conducting the Assessment of the Performance of Higher Education Applicants of Vasyl Stefanyk Precarpathian National University (Order of the Rector of Vasyl Stefanyk Precarpathian National University No. 309 of 19 May 2023) (<a href="https://nmv.pnu.edu.ua/wp-content/uploads/sites/118/2023/05/otzinnuvannja-uspishnosti.pdf">https://nmv.pnu.edu.ua/wp-content/uploads/sites/118/2023/05/otzinnuvannja-uspishnosti.pdf</a>)</p> <p>The Regulation is available at the link: <a href="https://nmv.pnu.edu.ua/нормативні-документи/polozhenja/">https://nmv.pnu.edu.ua/нормативні-документи/polozhenja/</a></p>