TOMSK POLYTECHNIC UNIVERSITY
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

Director of Nuclear Science & Engineering School
_______________ / Oleg Yu. Dolmatov
"25" 06 2020

**Course Name: Nuclear Physics**

**Field of Study:** Nuclear Science and Technology

**Programme name:** Nuclear Science and Technology

**Academic profile:** Nuclear medicine

**Level of Study:** Master Degree Programme

**Year of admission:** 2019

**Semester, year:** semester 1, year 1

**ECTS:** 4

**Total Hours:** 144

**Contact Hours:** 48

- **Lectures:** 16
- **Labs:** 16
- **Practical experience:** 16

**Self-study:** 96

**Assessment:** exam

**Division:** Nuclear Fuel Cycle

**Director of Programme** _______________ / Vera V. Verkhoturova

**Instructor** _______________ / Andrey O. Semenov

TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

## Course name: Nuclear Physics

## Course Overview

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| **Course Objectives** | The objective of the course is to develop knowledge and skills to perform professional activity in a variety of forms including research and technological activities in the fields related to nuclear power engineering. |
| **Learning Outcomes** | **Upon completion of the course, a graduate is expected to acquire the knowledge of:**<br>– main ways of interaction of neutron radiation, gamma-ray fluxes, light and heavy charged particles with matter;<br>– basic concepts and terms related to nuclear physics;<br>– theory of nuclei structure and their characteristics;<br>– types and laws of radioactive decays;<br>– mechanisms of nuclear reactions and their types;<br>**Graduates are also expected to develop the following skills:**<br>– to carry out calculations of the interaction of ionizing radiation with various materials and substances;<br>– to predict nuclear transformations based on radioactive series;<br>– to interpret characteristics and parameters of nuclei in accordance with the basic models of nuclei;<br>– to perform theoretical and experimental data analysis of radioactive transformations parameters;<br>– to apply knowledge of modern communicative technologies in a foreign language in the field of nuclear physics;<br>**Graduates should acquire the practical experience in:**<br>– use of mathematical analysis and modeling;<br>– theoretical study of the processes of interaction of flows of ionizing radiation with matter;<br>– carrying out evaluative and engineering calculations of the parameters of nuclear reactions;<br>– application of methods to analyze nuclear transformations of substances due to their decays, and interpretation of the obtained results. |
| **Course Outline** | The course is taught using a variety of teaching forms, including lectures, practical experience and learners' self-study.<br>The course includes the following obligatory components:<br>– 8 lectures;<br>– 8 practical experiences;<br>– 2 cycles of laboratory works;<br>– 3 tests (in a written form);<br>– 2 colloquiums.<br>**Main sections of the course are as follows:**<br>– Introduction<br>– Static properties of atomic nuclei<br>– Models of nuclei |

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| | – Radioactivity<br>– Fission and fusion of nucleus<br>– Interaction of radiation with matter<br>– Nuclear reactions.<br>The students will achieve learning objectives of the course after a series of lectures on nucleus and its structure, nature and laws of radioactivity, fission and fusion, interaction of radiation with matter and nuclear reactions. Students will apply obtained knowledge at practical classes to solve different problems and at labs developing professional and soft skills.<br>Practical training, tasks with theoretical questions and exercises have been developed for each course topic. Students will do a part of practical work in the classroom, whereas another part of practical work will be done individually as a self-study work.<br>Lab defense is assessed with the score of 5 points: 1 correct answer on question gives 1 score scores for the report defense. Four labs must be done within the course. The defense is required to provide a report on the work performed.<br>The current assessment allows revealing the quality of learners mastering the course material referring to all sections of the course “Nuclear Physics”. Test should be done in writing during the semester. 3 tests are planned for the semester. The structure of the test includes 2 test questions, 3 test exercises. Each test question is assessed with two points, test exercises – 1 score. The whole test is assessed with 7 points.<br>In order to assess the current level of knowledge, it is supposed to conduct 2 colloquiums in the form of an oral interview. It is necessary to answer on 5 theoretical questions based on the materials of the relevant sections of the discipline. The correct answer to this question is estimated at 2 points. The maximum possible number of points for one colloquium is 10 points.<br>The exam is a final assessment form. The exam purpose is to reveal developed learning outcomes and to determine the degree of correspondence of demonstrated learning outcomes to those expected in the program. A student is admitted to the exam on condition that all the tests are passed, all laboratory works are defended and the total score achieved is not less than 44.<br>The structure of an exam paper includes two questions. Each question is given 10 points. The maximum score for the exam is 20. The exam is oral: a student answers the lecturer’s questions and presents ways of the problem solution. Additional questions and tasks can be provided by a lecturer at the exam. A student must score at least 10 points to pass an exam. |
| **Prerequisites (if available)** | There are no special prerequisites to study this course. |
| **Course Structure** | The course material is divided into seven sections. Each section consists of lectures and practical experiences.<br>**Section 1. Introduction**<br>As a result of mastering the section, the student will know about the role of nuclear physics in the modern world, the connection of the course "Nuclear Physics" with other disciplines of the educational program Nuclear Power Engineering. Within the section, the student will also have an idea of the forces and interactions acting on atomic scales, the units of measure used for the magnitudes of the microcosm.<br>**Section 2. Static properties of atomic nuclei**<br>As a result of mastering the section, a student will know about a series of basic |

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| | properties of atomic nuclei, general models of nucleus and nuclear forces acted on nuclear scales.<br>**Section 3. Models of nuclei**<br>As a result of mastering the section, a student will know about the different models of atomic nuclei.<br>**Section 4. Radioactivity**<br>As a result of mastering the section, a student will know about radioactivity and basic laws of radioactive decay, types of radioactivity, measurement units of radioactivity, devices and methods for measuring radiation detection and measuring radioactivity. In addition, a student will be able to calculate main characteristics of decay reactions.<br>**Section 5. Fission and fusion of nucleus**<br>As a result of mastering the section, a student will know about main reactions in the area of nuclear power engineering, conditions for reactions behavior for fission and fusion, tasks and problems of nuclear power engineering. In addition, a student will be able to calculate main characteristics of fission and fusion reactions.<br>**Section 6. Interaction of radiation with matter**<br>As a result of mastering the section, a student will know specifics of ionizing radiation, principles of radiation interaction with matter, difference in interaction of light and heavy particles with matter. In addition, a student will be able to calculate main characteristics of ionizing radiation interaction with matter and a student will have practice in determining the characteristics of radioactive isotopes.<br>**Section 7. Nuclear reactions**<br>As a result of mastering the section, a student will know about different types of nuclear reactions, laws and behavior of nuclear reactions, specifics of some nuclear reactions. In addition, a student will be able to calculate nuclear reactions and their characteristics.<br>In the course, students will have four labs, three tests and one final test in the form of exam. |
| **Facilities and Equipment** | 1. Lecture rooms with multimedia equipment (projector, PC): 634050, Lenina Ave., building 10, room 340, room 228.<br>2. Room for practical experience with PC: 634050, Lenina Ave., building 10, room 248.<br>3. Laboratory of nuclear physics: 634050, Lenina Ave., building 10, room 248Б. |
| **Grading Policy** | In accordance with TPU assessment system we use:<br>– Current assessment which is performed on a regular basis during the semester by scoring the quality of mastering the theoretical material and the results of practical activities (tests, tasks, problem solving). Max score for current assessment is 80 points.<br>– Course final assessment (exam) is performed at the end of the semester. Max score for course final assessment is 20 points.<br>The final score is determined by summing the scores of the current assessment during the semester and exam score at the end of the semester. Maximum overall score corresponds to 100 points, min pass score is 55 points. |
| **Course Policy** | Class attendance will be taken into consideration when evaluating students' participation in the course. Students are expected to be actively engaged in class discussions on the assigned reading materials. All classes are obligatory to visit. |

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| | Medical allowance to work with radiation is required. Students should pass briefing about electrical, work and radiation safety in laboratories of Nuclear Fuel Cycle Division. |
| **Teaching Aids and Resources** | **Compulsory reading:**<br>1. Kamal, A. Nuclear Physics / A. Kamal. — Berlin : Springer-Verlag , 2014. — 612 p. –Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-642-38655-8 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ.<br>2. Takigawa N. Fundamentals of Nuclear Physics / N. Takigawa K. Washiyama. — Tokyo : Springer, 2017. — 269 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-55378-6 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ.<br>3. Marguet, S. The Physics of Nuclear Reactors / S. Marguet. — Cham : Springer International Publishing AG, 2017. — 1445 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-319-59560-3 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ.<br>**Additional reading:**<br>1. Saha, G. B. Physics and Radiobiology of Nuclear Medicine / G. B. Saha. — New York : Springer Science, 2013. — 328 с. – Текст: электронный // SpringerLink. – https://link.springer.com/book/10.1007/978-1-4614-4012-3 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ.<br>2. Greiner W. Nuclear Physics: Present and Future/ W. Greiner. — Cham : Springer International Publishing, 2015. — 309 с. — – Текст: электронный // SpringerLink. – https://link.springer.com/book/10.1007/978-3-319-10199-6 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. |
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