TOMSK POLYTECHNIC UNIVERSITY
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

Director of Nuclear Science & Engineering School
______________ / Oleg Yu. Dolmatov
"25" ___06___ 2020

Course Name: Radiation Physics

Field of study: Nuclear Science and Technology

Programme name: Nuclear Science and Technology

Specialization: Nuclear medicine

Level of Study: Master Degree Programme

Year of admission: 2020

Semester, year: semester 1, year 1

ECTS: 4

Total Hours: 144

Contact Hours: 16

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

Self-study: 96

Assessment: exam

Division: Nuclear Fuel Cycle

Director of Programme ______________ / Vera V. Verkhoturova

Instructor ______________ / Leonid G. Sukhikh

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Course name: Radiation physics

Course Overview

Course Objectives	The objective of the course is to form basic knowledge and appreciation in the field of radiation physics that includes variety of the processes of radiation interaction with the matter, radiation transfer, and basic principles behind the equipment for generation, usage, and measurement of radiation fields in medicine and biology
Learning Outcomes	**Upon completion of the course, a graduate will obtain the knowledge of:** • Classification of different types of ionizing radiations, units and quantities used for description of radiation fields and interaction of radiation with matter • Basics of generation, transfer and interaction with the matter for the photon, electron and proton beams • Basics of radiation dosimetry and main type of dosimeters: calorimetric dosimetry, chemical dosimetry, ionization chambers, relative dosimetry techniques **Upon completion of the course, graduates are expected to develop the following skills:** • To simulate the transfer of ionizing radiation (photon, electron, proton radiation) through the matter using Monte-Carlo techniques • To take a decision on optimal radiation source parameters (type, energy) for irradiation of the given volume **Upon completion of the course, graduates should acquire the practical experience in:** • Self-supporting (self-dependent) search, understanding, implementation, and presentation of information in the professional field • Use of specialized computational software (PCLab, Wolfram Mathematica) **The graduate will:** • Know the basics of the physics of the interaction of ionizing radiation with matter, the features of energy transfer to matter and the formation of dose fields in tissue-equivalent materials and air, the basics of generating ionizing radiation used in radiation therapy, diagnostics and interventional radiology. • Be able to calculate and simulate the distribution of the absorbed dose in the water generated by photons, electrons and protons of various energies and spectral composition • Know the physical and technical fundamentals of the operation of devices based on radionuclide and generating sources of ionizing radiation used in radiation therapy, diagnostics and interventional radiology • Know the physical and technical fundamentals of the operation of devices for measuring the characteristics of ionizing radiation sources used in radiation therapy, diagnostics and interventional radiology • Analyze the problem situation and task, search, extract and rank information, evaluate own resources and their limits (personal, situational,

	temporary ones), use them optimally for the successful completion of the assigned task • Compose standard business documentation for academic and professional purposes, academic and professional texts in a foreign language (Russian / English) • Organize a discussion of the results of research and design activities in a foreign language (English / Russian), choosing the appropriate format
Course Outline	The 'Radiation physics' course aims to achieve two main tasks, namely, to make sure that all students have basic knowledge needed for further professional training, and to prepare students for the concept of further study and obtaining of competences through learning, but not being taught, through self-study and self-support. The course is divided into three main types of classroom activities, lectures, practical tasks and labs that are aimed to give minimal knowledge and abilities for further learning. During the lectures the basic ideas and concepts will be presented to the students. The practical trainings will be used for both solution of the practical tasks and for discussion of the theoretical material as well as for presentation of the students' self-obtained results. Labs will be devoted to simulation of ionizing radiation fields and interaction with matter and to demonstration of basics of the physical processes using radiation sources and detectors. The training course is delivered through the following teaching modes: – 8 lectures; – 8 practical experiences; – 8 laboratory works. The course consists of 4 sections, which are given below. **Section 1. Introduction** **Section 2. Indirectly ionizing radiation** **Section 3. Directly ionizing radiation** **Section 4. Detectors of ionizing radiation** Each section includes several lectures, practical experiences and laboratory works.
Course Structure	The course material consists of four main sections. Each part includes lections and practical training: **Section 1. Introduction** Introduction part includes main terms and concepts of radiation types, basic quantities and units used for radiation field description and description of interaction of ionizing radiation with matter. **Section 2. Indirectly ionizing radiation** The second part includes topics associated with x-ray generation, laws of exponential attenuation and photon interaction with matter. The student will obtain knowledge about bremsstrahlung generation, x-ray units, high-energy x-rays from charged particle accelerator, characteristic x-rays, photon beam quality and filtering, photon exponential attenuation, half-value and tenth-value layers, buildup factor, spectral effects (hardening and softening), energy transfer and absorption coefficient, calculation of absorbed energy of photon beams, photon interaction with matter, Thomson, Rayleigh, Compton scattering, photoelectric effect, pair production, fluorescence yield, Auger effect, contribution of individual effects to attenuation coefficient, energy transfer and energy absorption **Section 3. Directly ionizing radiation** The third part includes topics associated with interaction of charged particles with

	the matter. The student will obtain knowledge about types of charged particles used clinically, sources of charged particle beams, energy deposition in tissue by charged particles, collisional and radiative stopping power, scattering power, range, straggling, restricted stopping power, linear energy transfer, electron interaction, calculation of absorbed dose in charged particle interaction **Section 4. Detectors of ionizing radiation** The fourth part includes topics associated with detection of ionizing radiation with respect to medicine and biology. The student will obtain knowledge about charged particles and radiation equilibrium, basics of radiation dosimetry, calorimetric dosimetry, chemical (Fricke) dosimetry, cavity theory, ionization chambers, relative dosimetric techniques, dosimetry by pulse-mode detectors. The course labs is devoted to the simulation of the radiation transfer through the matter and simulation of dose distributions in water
Facilities and Equipment	1. Lecture rooms with multimedia equipment (projector, PC): 228 room of the 10th building of TPU, 125A room of the 10th building of TPU. 2. Rooms for practical experience with PC: 228 room of the 10th building of TPU, 125A room of the 10th building of TPU, 123 room of the 10th building of TPU. 3. Laboratories: laboratory of spectroscopy 123 room of the 10th building of TPU, computational class, 122 room of the 10th building of TPU. 4. Laboratory equipment includes gamma-ray sources, detectors of gamma radiation, dosimeters and photon counters. PcLab software for simulation interaction of photons, electrons and protons with matter, Wolfram Mathematica software for data treatment and preparation of reports.
Grading Policy	In accordance with TPU assessment system we use: - 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. - Course final assessment (exam) is performed at the end of the semester. Max score for course final assessment is 20 points. Lab defense is assessed with the score of 5 points: 2 points are allocated for the preparation of the report and 3 scores for the report defense. Eight labs must be done within the course. The defense is required to provide a report on the work performed. The current assessment allows revealing the quality of learners mastering the course material referring to all sections of the course “Radiation Physics”. Test should be done in writing during the semester. Three tests are planned for the semester. The structure of the test includes two test questions, one test exercise and one test task. Each task is assessed with one point, teat task – two points. The whole test is assessed with 5 points. 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. The structure of an exam paper includes two questions and two tasks. Each question and task is given five 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. 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 62 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. All labs and practical tasks should be fulfilled to pass the course. 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:** 1. Podgorsak, Ervin B. Radiation Physics for Medical Physicists / Ervin B. Podgorsak. – Cham : Springer International Publishing, - 2016. — 906 p. — Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-319-25382-4 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 2. Podgorsak, Ervin B. Compendium to Radiation Physics for Medical Physicists / Ervin B. Podgorsak. — Berlin: Springer-Verlag, 2014. – 1148 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-642-20186-8 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 3. Amestoy, William. Review of Medical Dosimetry / William Amestoy. - Cham : Springer International Publishing, - 2015. — 867 p. — Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-319-13626-4 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ 4. Cerrito, L. Radiation and Detectors: Introduction to the Physics of Radiation and Detection Devices / Lucio Cerrito. – Cham: Springer International Publishing, 2017. – 210 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-319-53181-6 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. **Additional reading:** 1. An Introduction to Medical Physics / by editor Muhammad Maqbool. – Cham: Springer International Publishing, 2017. – 416 p. – Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-3-319-61540-0 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ.
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