TOMSK POLYTECHNIC UNIVERSITY | ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

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

Course Name: Clinical Dosimetry

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: 2019

Semester, year: semester 2, year 1

ECTS: 3

Total Hours: 108

Contact Hours: 48

- **Lectures:** 8
- **Labs:** 32
- **Practical experience:** 8

Assessment: Credit-test

Division: Nuclear Fuel Cycle

Director of Programme _____________ / Vera V. Verkhoturova

Instructor _____________ / Evgeniia S. Sukhikh

Course Name: Clinical Dosimetry

Course Overview

Course Objectives	One of the main tasks of medical physicists working in radiotherapy departments is the technical and dosimetric control of radiotherapy devices operation quality, which include gamma apparatus (Co^{60} radionuclide), X-ray tubes, devices for intracavitary and interstitial radiation therapy (brachytherapy), high-energy electronic accelerators, which are able both to generate a therapeutic beam of bremsstrahlung radiation, and to conduct treatment with electrons. Dosimetric quality control includes basic procedures for clinical dosimetry of radiation beams, namely, measurement of distribution of the absolute and relative dose generated by the device. Clinical dosimetry is carried out using special dosimetric equipment: ionization detectors (cylindrical and plane-parallel chambers), semiconductor detectors and phantoms (water and solid ones) in accordance with international dosimetric protocols. Within the framework of this discipline, all necessary procedures for calibrating photon and electron beams of high energies (1-50 MeV), as well as X-ray beams of low energies (30-100 keV) and medium energies (100-400 keV) for external and contact radiation therapy based on International protocols (TRS-398, TG-51, TG-25, TG-61, TG-43) are learned and tested. Determination of absorbed dose in water for beams of different qualities, as well as determination of their characteristics (distribution of the percentage depth dose, determination of beam energy, transverse beam profile, flatness and beam symmetry, and beam output factors) is carried out. Measurement of beam characteristics in water (Blue Phantom, Dose Field Analyzer (IBA Dosimetry)) and solid-state phantom (SP34 (IBA Dosimetry)) are performed with using ionization chambers (cylindrical and plane-parallel) on therapeutic units (Theratron Equinox 100, Multisource HDR, Xstrahl 300, Elekta Synergy). The purpose of the discipline includes the formation of physical ideas about the features of the application of photon, proton and electron beams in radiation therapy, the knowledge of approaches and principles of clinical dosimetry of photon, proton and electron radiation, the specifics of the quality assurance of radiation therapy using these types of radiation. Discipline includes the learning of modern protocols for determining the absorbed dose in the aquatic environment, dose calculation methods, quality control in radiotherapy with photon proton and electron beams.
Learning Outcomes	As a result of mastering the discipline "CLINICAL DOSIMETRY", the master student should achieve the following results: <u>A specialist should have an idea:</u> • on the characteristics of beams of photon, proton and electron radiation used in radiation therapy, • on the technologies and equipment for correct diagnostics of ionizing beams characteristics that are used in radiotherapy, • application of international protocols for clinical dosimetry of electron, proton and photon beams for specific equipment. <u>The specialist should know and be able to use:</u> • the characteristics of photon, proton and electron beams, the spatial distribution of the absorbed dose in the tissue-equivalent medium for a critical analysis of their applicability as an instrument in the treatment of malignant neoplasms,

	• methods for assessing the determination of the absorbed dose in the tissue-equivalent medium when performing radiation therapy on photon, proton and electron beams, • methods of calibration of photon, proton and electron beams for radiotherapy, • the basic principles of the operation of therapeutic and dosimetry equipment. The specialist should be able to: • determine the absorbed dose, based on the technological parameters of the equipment and the properties of the radiation beam, • determine the main parameters of photon, proton and electron beams in a three-dimensional water space, • to carry out adjustment and calibration of radiotherapeutic and dosimetric equipment, As a result of mastering the discipline (module), the student should achieve the following results: 1) Ability to conduct clinical dosimetry of ionizing radiation beams for various radiotherapy equipment. 2) Ability to calculate the absorbed dose from the dosimeter's hardware units for specific measurement conditions. 3) Knowledge of modern approaches to the problem of clinical dosimetry of ionizing radiation beams. Objectives of the discipline: • Mastering terms, concepts, basic processes in the interaction of clinical beams of ionizing radiation with matter, the principles of clinical dosimetry of electronic and photon, proton beams of various energies (qualities); • Forming a scientific worldview among students, the ability to objectively assess the accuracy of measuring the doses of clinical apparatuses and critically evaluate available techniques; • Mastering the methods and obtaining skills to work with equipment for clinical dosimetry, mastering the rules for working with clinical sources of ionizing radiation; • Development of critical thinking skills in evaluating the results of measurement of absolute and relative distributions of the absorbed dose of clinical equipment.
Course Outline	The course consists of one section which include: – 4 lectures (8 class hours); – 4 practical classes (8 class hours); – 5 laboratory works (32 class hours).
Course Structure	**Lecture 1. The main characteristics describing the clinical dosimetry of therapeutic beams and high-energy photon beams.** Radiation therapy is described as a method of treating malignant neoplasms. The description of the types of therapeutic equipment (devices based on radionuclide sources, electronic accelerators for electronic and photon therapy, as well as modern equipment for stereotactic radiotherapy and radiosurgery (gamma knife and cyber-knife)), the basic principles of their operation and special additional equipment for modification and formation of various radiation fields (lead blocks, compensators, boluses, multicollimator). Descriptions are made that are intended for remote therapy and brachytherapy (intracavitary and interstitial). And then are described dosimetry equipment's for clinical dosimetry (water and plastic phantom, set of ionization chamber, electrometer) and the principle of their use in clinical dosimetry of photon and electron beams with therapeutic range of energy.

	The basics of clinical dosimetry, the values and units used to describe the characteristics of the ionizing radiation beam are presented. The rules for the use of detectors, the calibration of radiotherapeutic beams during the commissioning and in clinical practice, methods for determining the absorbed dose for photon beams (from ^{60}Co and higher energy) are described. The approaches in the application of the international protocols IAEA TRS-398 and AAPM TG-51 for determining the absorbed dose in water from photon radiation are shown. And also protocol AAPM TG-21 are described for determining the absorbed dose for photon beams. **Lecture 2. The main characteristics describing the clinical dosimetry of therapeutic electron beams of high energies.** The lecture gives basic information about the characteristics of the electron beam and the main principles of its clinical dosimetry according to the international protocols IAEA TRS-398, AAPM TG-51, AAPM TG-25 and also AAPM TG-21. The approaches in the application of the international protocol IAEA TRS-398 for determining the absorbed dose in water from proton beam are shown. **Lecture 3. The main characteristics describing the clinical dosimetry of therapeutic X-ray beams of low and medium energies:** This lecture gives the description of the characteristics of an X-ray beam of low and medium energies, for example, the quality of an X-ray beam which is to express in term of half-layer of attenuation HVL. Within the framework of the lecture, the main methods for determining the absorbed dose in a tissue equivalent medium according to the international protocols are shown. **Lecture 4. The main characteristics describing the clinical dosimetry of therapeutic gamma beams for brachytherapy equipment:** Brachytherapy is a method of treatment in which a sealed radioactive source is used to deliver radiation over a short distance. With this method of therapy, a high dose of radiation can be delivered locally to the tumor with a rapid drop in the dose to the surrounding normal tissue. The lecture gives basic information about the design features of sources for brachytherapy and the main principles of clinical dosimetry of radioactive sources according to international protocols. **Practical lesson № 1.** Entry test questions for determining the degree of readiness of students to master the course "Clinical Dosimetry". Students should pass entry test in writing at the beginning of the practical classes №1. And then student's discus about operation principle of various types detectors which can be used in clinical dosimetry of therapeutic beams in the form presentations. **Practical lesson № 2**. Current assessment test questions and tasks for photon beams high energy according to protocols IAEA TRS-398, AAPM TG-51, AAPM TG-21. **Practical lesson № 3.** Current assessment test questions and tasks for photon, proton and electron beams high energy according to protocols IAEA TRS-398, AAPM TG-51, AAPM TG-21, AAPM TG-25. **Practical lesson № 4.** Current assessment test questions and tasks for low and medium energy X-ray radiation (IAEA TRS-398, AAPM TG-61) and for radionuclide sources that are used in brachytherapy. **Laboratory work 1**. Learning of water phantom - Blue Phantom and clinical dosimetry of photon beams of high energies on the therapeutic beam of the gamma equipment for external beam radiotherapy Theratron Equinox 100. **Laboratory work 2**. Clinical dosimetry of low and medium energy X-ray beams for orthovoltage radiotherapy (Xstrahl 300). **Laboratory work 3.** Clinical dosimetry of the gamma radiation beam on the brachytherapy equipment (Multisource HDR).

	Laboratory work 4. Clinical dosimetry of photon beams of high energies on the therapeutic beam of the Elekta Synergy linear accelerator. **Laboratory work 5**. Clinical dosimetry of electron beams of high energies on the therapeutic beam of the Elekta Synergy linear accelerator.
Facilities and Equipment	1. Lecture rooms with multimedia equipment (projector, PC): 634050, Tomsk, Lenina Ave., 2, building 10, room 123, 125A. 2. Water phantom Blue Phantom (analyzer of dosing fields), Tomsk Regional Oncology Center. 3. Electrometer DOSE-1, Tomsk Regional Oncology Center. 4. Set of ionization chambers for absolute and relative dosimetry, Tomsk Regional Oncology Center. 5. Set of diodes: PTW T9113 and PTW T9112, Tomsk Regional Oncology Center. 6. Programme of OmniPro, Tomsk Regional Oncology Center. 7. Phantoms: MatriXX, ArcCHECK, SP34, PTW T9193, Tomsk Regional Oncology Center. 8. Theratron Equinox 100 (Co60 radionuclide), Tomsk Regional Oncology Center. 9. Linear accelerator Elekta Synergy, Tomsk Regional Oncology Center. 10. Multisource HDR (Co^{60} radionuclide), Tomsk Regional Oncology Center. 11. Xstrahl-300 (60-300 keV), Tomsk Regional Oncology Center.
Grading Policy	In accordance with TPU rating system we use: – Current assessment which is performed on a regular basis during the semester by scoring the quality of mastering of theoretical material and the results of practical activities (performance tests, perform tasks, problem solving). Max score for current assessment is 40 points, min – 22 points. – Course final assessment (exam/ credit test) is performed at the end of the semester. Max score for course final assessment is 60 points, min – 33 points. The final rating is determined by summing the points of the current assessment during the semester and defense of term project at the end of the semester. Maximum overall rating corresponds to 100 points, min pass score is 55.
Course Policy	Attendance is strictly controlled. All classes are obligatory for attendance.
Teaching Aids and Resources	**Compulsory reading:** 1. 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. 2. Stereotactic Body Radiation Therapy / by editor Yasushi Nagata. — Tokyo: Springer, - 2015. – 254 p. — Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-4-431-54883-6 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. 3. Brachytherapy. Techniques and Evidences / by editors Y.Yoshioka, J. Itami, M. Oguchi, T. Nakano. - Singapore: Springer, 2019. – 304 p. — Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-981-13-0490-3 (дата обращения: 20.09.2020). – Режим доступа: из корпоративной сети ТПУ. **Additional 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.
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