Subject card

Subject name and code	Modern Techniques in Radiotherapy, PG_00182360					
Field of study	Medical Physics					
Date of commencement of studies	October 2026		Academic year of realisation of subject		2026/2027	
Education level	Master’s studies		Subject group		Obligatory subject group in the field of study Subject group related to scientific research in the field of study	
Mode of study	full-time studies		Mode of delivery		at the university	
Year of study	1		Language of instruction		Polish	
Semester of study	1		ECTS credits		2.0	
Learning profile	academic		Assessment form		exam	
Conducting unit						
Name and surname of lecturer (lecturers)	Subject supervisor		dr inż. Joanna Kamińska			
	Teachers					
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	0.0	0.0	0.0	30
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours	Self-study	SUM
	Number of study hours	30		0.0	20.0	50
Subject objectives	The objective of this course is to familiarize students with advanced and innovative techniques used in contemporary radiotherapy. Students will gain theoretical knowledge and a practical understanding of key aspects of treatment planning, patient monitoring, and quality control in radiotherapy. The curriculum focuses on the latest technological advancements, such as adaptive radiotherapy, the application of artificial intelligence, SGRT systems, and innovative devices (MRI-Linac, Tomotherapy). The goal is to prepare students to consciously and responsibly use advanced tools, as well as to evaluate their potential and limitations in clinical practice.					

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZMEDMU2_W06] Knows and understands the current directions of development of physics and medical sciences, especially in the field of medical physics, and the fundamental dilemmas of modern civilisation.	The student recognizes and describes the role of artificial intelligence (AI) in treatment planning and process automation in radiotherapy. They list the benefits and limitations of SGRT systems and knowledge-based planning (RapidPlan) in improving treatment precision. They identify the fundamental ethical dilemmas and clinical safety issues associated with the growing use of AI in medicine. The student explains the importance of independent treatment plan verification (e.g., using the Mobius system) as a key element of quality assurance.	[SW4] test/exam - oral or written
	[FIZMEDMU2_W01] Knows and understands in depth selected issues in the field of physics and medicine, the complex relationships between them, and development trends in the exact and natural sciences, health sciences, and others.	The student classifies various stereotactic techniques (SRS, SBRT) and their clinical applications in cancer treatment. They identify selected clinical indications for the use of electrons, TBI (Total Body Irradiation) techniques, and brachytherapy. They also point out the complex relationships between beam physics and clinical outcomes in modern techniques for breast and cardiac irradiation (e.g., in the STOPStorm project).	[SW4] test/exam - oral or written
	[FIZMEDMU2_W04] Knows and understands in depth the theoretical foundations and principles of operation of measurement systems and research, diagnostic and therapeutic equipment specific to the field of physics and medicine.	The student describes the theoretical foundations of adaptive radiotherapy and the role of 3D boluses in therapeutic dose shaping. They characterize the operating principles and construction of innovative medical accelerators, such as MRI-Linac, Zap-X, and Tomotherapy. The student explains the methodology of end-to-end tests and their importance in ensuring the quality and safety of radiotherapy systems. They also differentiate between the computational algorithms used in treatment planning systems, pointing out their key features and applications.	[SW4] test/exam - oral or written
	[FIZMEDMU2_K02] Is ready to create, adhere to and develop patterns of good conduct, including the principles of professional ethics and intellectual honesty in one's own activities and in the work environment; is aware of ethical issues in the context of research integrity and in the work of a medical physicist.	The student is ready to understand and identify ethical issues related to the growing use of artificial intelligence (AI) in radiotherapy treatment planning and diagnostics. They demonstrate awareness of the responsibility for treatment quality and safety, including through the active use of end-to-end procedures and independent plan verification (e.g., Mobius). They also appreciate the importance of teamwork and engage in discussions about the role of a medical physicist in an interdisciplinary therapeutic team. The student is ready to recognize and act in accordance with the principles of professional ethics, especially concerning dosimetry and dose optimization in innovative techniques like adaptive radiotherapy or TBI. They analyze issues of intellectual honesty, particularly regarding the use of clinical data and models in systems like RapidPlan.	[SK4] test/exam - oral or written

Subject contents	
	1. Adaptive Radiotherapy New Opportunities and Challenges A discussion of the adaptive radiotherapy concept, its technological and clinical foundations, as well as the potential benefits for patients and practical limitations. **2. The Application of Artificial Intelligence in Radiotherapy** An overview of AI tools in treatment planning, image analysis, and process automation. A discussion of ethical challenges and clinical safety. **3. 3D Boluses Design and Clinical Application** The role of boluses in dose shaping, modern 3D design techniques, and examples of their use in the treatment of skin and head and neck cancers. **4. End-to-End Tests in Radiotherapy Importance and Examples** The significance of comprehensive testing of radiotherapy systems. Examples of e2e procedures and their impact on treatment safety. **5. Algorithms in Treatment Planning Systems Potential and Limitations** A discussion of various computational algorithms used in planning. An analysis of their accuracy, speed, and clinical limitations. **6. SGRT High Precision in Surface Radiotherapy** The application of Surface-Guided Radiation Therapy (SGRT) systems in patient monitoring. The advantages of SGRT in improving accuracy and reducing immobilization. **7. The Use of Electrons in Modern Radiotherapy** Clinical indications for the use of electrons. Modern techniques and planning of electron beams. **8. The STOPStorm Project An Innovative Approach to Cardiac Irradiation** A presentation of the international STOPStorm project. Techniques and procedures enabling safe cardiac irradiation in selected disease units. **9. The TBI Technique Total Body Irradiation** Clinical applications, techniques for implementing TBI in clinical practice, and physical and planning aspects. **10. Stereotaxy in Cancer Treatment Current Solutions** An overview of contemporary stereotactic techniques (**SRS**, **SBRT**). Applications in the treatment of brain, lung, and other cancer sites. **11. Breast Irradiation Techniques and Optimization** Different technical approaches in treating breast cancer. Methods for optimizing plans and limiting the dose to critical organs. **12. Brachytherapy of the 21st Century Trends and Directions for Development**

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<tr><td></td><td>Modern applications of brachytherapy. The development of planning and imaging techniques and the possibilities for treatment personalization.

13. RapidPlan Knowledge-Based Planning

The concept of knowledge-based planning. Its advantages, limitations, and examples of clinical applications.

14. Mobius in Radiotherapy Independent Plan Verification

Tools for the independent verification of treatment plans. The use of the Mobius system in ensuring radiotherapy quality.

15. Modern Technologies: MRI-Linac, Zap-X, and Tomotherapy

An overview of innovative devices and systems for radiotherapy. Clinical possibilities, technological advantages, and implementation challenges.</td></tr>
<tr><td>Prerequisites
and co-requisites</td><td></td></tr>
<tr><td>Assessment methods
and criteria</td><td><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>open-answer test</td><td>51.0%</td><td>100.0%</td></tr>
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Recommended reading	Basic literature	1. **Radioterapia adaptacyjna nowe możliwości i wyzwania** • Yan D., Vicini F., Wong J., Martinez A. *Adaptive radiation therapy*. Phys Med Biol. 1997. • IAEA. *Adaptive Radiation Therapy*. Human Health Reports, 2019. 2. **Zastosowanie sztucznej inteligencji w radioterapii** • Bibault J.E., Giraud P., Burgun A. *Big Data and Machine Learning in Radiation Oncology: State of the Art and Future Prospects*. Cancer Lett. 2016. • Thompson R.F., Valdes G. *Artificial Intelligence in Radiation Oncology*. Springer, 2021. 3. **Bolusy 3D projektowanie i wykorzystanie w praktyce klinicznej** • Canters R.A.M. et al. *Clinical implementation of 3D printed bolus in radiotherapy*. Radiother Oncol. 2016. • Khan F.M. *The Physics of Radiation Therapy*. 5th ed., Lippincott Williams & Wilkins, 2014. 4. **Testy end-to-end w radioterapii znaczenie i przykłady** • IAEA. *Comprehensive audits of radiotherapy practices: a tool for quality improvement*. IAEA Human Health Series, 2007. • AAPM TG-142. *Quality assurance of medical accelerators*. Med Phys. 2009. 5. **Algorytmy w systemach planowania leczenia potencjał i ograniczenia** • Rogers D.W.O. *Fifty years of Monte Carlo simulations for medical physics*. Phys Med Biol. 2006. • Khan F.M. *The Physics of Radiation Therapy*. 6. **SGRT wysoka precyzja w radioterapii powierzchniowej** • Bert C., Metheany K.G., Doppke K.P. *Clinical experience with surface guided radiotherapy*. Radiother Oncol. 2016. • VisionRT. *Clinical Guide to SGRT*. 7. **Wykorzystanie elektronów w nowoczesnej radioterapii** • Khan F.M. *The Physics of Radiation Therapy*. • Podgorsak E.B. *Radiation Oncology Physics: A Handbook for Teachers and Students*. IAEA, 2005. 8. **Projekt STOPStorm innowacyjne podejście do napromieniania serca** • Cuculich P.S. et al. *Noninvasive cardiac radiation for ablation of ventricular tachycardia*. N Engl J Med. 2017. • Strona projektu: www.stopstorm.eu. 9. **Technika TBI całkowite napromienianie ciała** • IAEA. *Total body irradiation: Techniques and clinical applications*. Human Health Series, 2018. • Wong J.Y.C., Liu A. *Total Body Irradiation: A Practical Guide to Clinical Implementation*. Springer, 2017. 10. **Stereotaksja w leczeniu nowotworów aktualne rozwiązania** • Potters L. et al. *American Society for Therapeutic Radiology and Oncology (ASTRO) and American College of Radiology (ACR) practice guidelines for stereotactic body radiation therapy (SBRT)*. Int J Radiat Oncol Biol Phys. 2010. • Timmerman R. *Stereotactic body radiation therapy*. Springer, 2014. 11. **Napromienianie piersi techniki i optymalizacja** • Darby S.C. et al. *Risk of ischemic heart disease in women after radiotherapy for breast cancer*. N Engl J Med. 2013. • IAEA. *Radiotherapy in Breast Cancer: A Practical Guide*. Human Health Series, 2016. 12. **Brachyterapia XXI wieku trendy i kierunki rozwoju** • Baltas D., Tselis N. *The Modern Brachytherapy*. Springer, 2021. • Hoskin P.J., Coyle C. *Radiotherapy in Practice Brachytherapy*. Oxford University Press, 2nd ed., 2019. 13. **RapidPlan planowanie oparte na wiedzy** • Fogliata A., Belosi F., Nicolini G. *Knowledge-based treatment planning: an overview*. Radiother Oncol. 2017. • Varian Medical Systems. *RapidPlan User Guide*. 14. **Mobius w radioterapii niezależna weryfikacja planów** • Halvorsen P.H. *Role of secondary dose calculation software for IMRT QA*. J Appl Clin Med Phys. 2008. • Mobius Medical Systems. *Mobius3D and MobiusFX White Papers*. 15. **Nowoczesne technologie: MRI-Linac, Zap-X i tomoterapia** • Raaymakers B.W. et al. *First patients treated with a 1.5 T MRI-linac: clinical proof of concept of a high-precision, high-field MRI guided radiotherapy treatment*. Phys Med Biol. 2017. • Adler J.R. et al. *The Zap-X system for non-invasive brain radiosurgery*. Cureus. 2019. • Mackie T.R. et al. *Tomotherapy: concepts, design, and clinical applications*. Int J Radiat Oncol Biol Phys. 1993.
	Supplementary literature	not applicable
	eResources addresses	

Example issues/ example questions/ tasks being completed	
Work placement	Not applicable

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