GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Modern manufacturing techniques in medical application, PG_00065015						
Field of study	Mechanical and Medical Engineering						
Date of commencement of studies	February 2025		Academic year of realisation of subject	2025/2026			
Education level	second-cycle 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	2		ECTS credits	2.0			
Learning profile	general academic profile		Assessment form	assessment			
Conducting unit	Zakład Materiałoznawstwa I Technologii Materiałowych -> Institute of Manufacturing and Materials Technology -> Faculty of Mechanical Engineering and Ship Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. inż. Marek Szkodo				
	Teachers						
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	0.0	15.0	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		6.0	14.0		50
Subject objectives	The aim of the course is to familiarize students with modern manufacturing techniques used in medicine, including 3D printing, nanotechnology, bioprinting, and smart materials, as well as to develop practical skills in applying these technologies in diagnostics, treatment, tissue regeneration, and the creation of personalized medical tools and implants.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K7_K13] is ready for responsible performance of proffesional roles, considering ever-changing need of the society, including self developement and supporting and fullfiling work ethics	Knowledge: The student knows the ethical principles related to the application of modern technologies in medicine, such as 3D printing, nanotechnology, and bioprinting, in the context of responsibility toward patients and society. They understand the significance of an interdisciplinary approach to the development of medical technologies and their impact on improving the quality of life. Skills: The student is able to identify potential ethical and social risks associated with the use of modern technologies in medicine, such as tissue bioprinting or 3D-printed implants. They can present and justify the selection of medical technologies, considering social needs, ethical principles, and environmental impact. The student is capable of communicating with various stakeholder groups, including patients, medical teams, and academic institutions, in a clear and understandable manner, emphasizing the societal benefits of modern technologies. Social Competencies: The student is aware of their professional responsibility for the outcomes of applying modern technologies in medicine and their societal impact. They uphold and develop the ethos of the engineer and medical specialist profession, acting in accordance with professional ethical standards in the context of introducing new technologies. The student demonstrates a readiness to engage in activities aimed at developing socially responsible medical technologies that address evolving social needs. They maintain a critical approach to the implementation of new technologies, considering their impact on public health, equality of access to treatment, and the needs of marginalized groups.	[SK4] Assessment of communication skills, including language correctness

Course outcome	Subject outcome	Method of verification
[K7_U13] evaluates the feasibility and potential for utilizing new technical and technological achievements in accomplishing tasks characteristic for the field of study	Knowledge: The student knows the fundamental principles and technologies used in modern manufacturing techniques in medicine, such as 3D printing, nanotechnology, bioprinting, and tissue engineering. They understand the possibilities and limitations of modern manufacturing technologies in medical applications, such as creating implants, prostheses, surgical tools, and anatomical models. The student possesses knowledge about materials used in modern manufacturing techniques, including biocompatible materials, nanostructures, and biomaterials. Skills: The student is able to analyze the applicability of modern manufacturing techniques in specific medical applications and assess their effectiveness. They can design basic anatomical models and structures using CAD software and 3D printing technology. The student evaluates the feasibility of implementing new technologies in medical practice, taking into account technological, economic, and ethical aspects. They utilize simulation and computational tools to analyze the durability and functionality of designed medical components. Social Competencies: The student is capable of collaborating within interdisciplinary teams on projects utilizing modern technologies in medicine. They are aware of the ethical and responsible application of modern technologies in the field of healthcare. The student recognizes the need for continuous improvement of their knowledge and skills in the face of the dynamic development of manufacturing technologies in medicine.	[SU5] Assessment of ability to present the results of task

Course outcome	Subject outcome	Method of verification
[K7_W04] has structured and well-founded knowledge covering issues in the field of mechanical engineering allowing to design medical devices, rehabilitation systems and to formulate research procedures	Knowledge: The student knows the basic principles of designing medical devices and rehabilitation systems using modern manufacturing technologies, such as 3D printing, bioprinting, and nanotechnology. They possess knowledge about the application of mechanical engineering in the design and analysis of medical devices, including the principles of material strength, biomechanics, and computer modeling techniques. The student understands the methodology of creating and implementing research procedures, taking into account normative requirements and the specific characteristics of medical devices. Skills: The student is able to design a simple medical device or rehabilitation system, considering user requirements, ergonomics, and safety. They use computer-aided design (CAD) tools and simulation methods (e.g., FEM) to analyze the functionality and durability of medical devices. The student formulates and implements research procedures, considering the specifics of medical devices and the requirements of safety and biocompatibility standards. They evaluate the properties of materials and their suitability for designing medical devices, including biocompatible materials, polymers, metals, and composites. The student analyzes and optimizes the structures of medical devices, considering technological and economic aspects. Social Competencies: The student understands the responsibility of an engineer for the safety and quality of medical devices, both in the context of their design and use. They demonstrate readiness to collaborate with interdisciplinary teams, including doctors, therapists, and regulatory specialists, in the design of medical devices. The student is aware of the necessity to comply with norms and technical standards in the process of designing and testing medical devices. They recognize the need for continuous knowledge and skill development in the context of the dynamic advancement of technologies used in medical engineering.	[SW2] Assessment of knowledge contained in presentation

Course outcome	Subject outcome	Method of verification
[K7_W13] explains the main principles of individual and teamwork organization, including various forms of entrepreneurship utilizing knowledge from the field of engineering and technical sciences and disciplines relevant to the course of study	Knowledge: The student knows the fundamental principles of project work organization using modern manufacturing techniques, such as 3D printing, bioprinting, and nanotechnology. They understand the specifics of teamwork in interdisciplinary projects encompassing materials engineering, manufacturing techniques, and medical applications. The student is familiar with various forms of technological entrepreneurship, including start-ups, business incubators, and methods for commercializing solutions based on modern medical technologies. Skills: The student is able to organize individual and team work during the execution of projects involving the design and implementation of innovative technologies in medicine. They can utilize project management tools, such as scheduling, resource management, and progress monitoring, in the context of teamwork on engineering projects. The student applies effective communication and collaboration methods in interdisciplinary teams that include engineers, medical specialists, and other stakeholders. They are capable of planning the commercialization process of technologies, taking into account technological, economic, and market aspects. The student develops prototypes and models as part of team projects, using knowledge of modern manufacturing techniques. Social Competencies: The student appreciates the importance of teamwork in fostering technological innovation, particularly in projects requiring collaboration among specialists from diverse fields. They are ready to take initiative and demonstrate entrepreneurial skills in implementing technological projects in the field of medicine. The student demonstrates responsibility for assigned tasks within a team, considering team objectives and principles of effective collaboration. They understand the need to support innovation and entrepreneurship in academic and professional environments as key elements of the development of engineering and technical sciences.	[SW3] Assessment of knowledge contained in written work and projects

Subject contents

Introduction to Modern Manufacturing Techniques in Medicine:

- **History of technological development in medicine.**
- **The role of modern technologies in improving the quality of healthcare.**

3D Printing in Medicine:

- **Principles of 3D printing technologies (FDM, SLA, SLS, DMLS).**
- **Applications of 3D printing in creating anatomical models, implants, prostheses, and surgical tools.**
- **Medical personalization through additive manufacturing technologies.**

Nanotechnology in Medicine:

- **Nanoparticles as drug carriers.**
- **Applications of nanomaterials in diagnostics and medical imaging.**
- **Biosensors based on nanotechnology.**

Bioprinting and Tissue Engineering:

- **Processes and technologies of bioprinting (inkjet, extrusion, laser-assisted).**
- **Applications of bioprinting in skin, cartilage, and soft tissue regeneration.**
- **Development of scaffolds and organoids.**

Smart Materials in Medicine:

- **Shape-memory materials (e.g., shape-memory alloys) and their applications.**
- **Biocompatible and biodegradable materials in implants and medical devices.**

The Future of Modern Manufacturing Techniques in Medicine:

- **Integration with robotics and artificial intelligence.**
- **Development of multi-material technologies and their applications.**
- **Technological, ethical, and regulatory challenges.**

Commercialization of Modern Medical Technologies:

- **Overview of business models in medical technology.**
- **The commercialization process of medical solutions.**
- **Standards, regulations, and certification of medical devices.**

Prerequisites and co-requisites

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Lectures - final quiz, duration: 45 minutes	50.0%	50.0%
Project - presentation	50.0%	50.0%

Recommended reading

Basic literature

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing"Autorzy: Ian Gibson, David W. Rosen, Brent Stucker

2. Bioprinting: Principles and Applications. Autorzy: Chee Kai Chua, Wai Yee Yeong

3. Nanotechnology in Medicine and Biology. Autorzy: Tuan Vo-Dinh

4. Introduction to Biomaterials: Basic Theory with Engineering Applications. Autorzy: C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford, Gopinath Mani

5. Smart Materials and Structures. Autorzy: M. V. Gandhi, B. S. Thompson

	Supplementary literature	1. Medical Instrument Design and Development. Autorzy: Claudio Becchetti, Alessandro Neri 2. Engineering Tissue Culture: Scaffolds, Biomaterials, and Bioreactors. Autorzy: Yusuf Khan, Cato T. Laurencin 3. Normy i regulacje dotyczące urządzeń medycznych i materiałów biokompatybilnych (ISO 10993, ISO 13485).
	eResources addresses	Adresy na platformie eNauczanie:
Example issues/ example questions/ tasks being completed	3D Printing: • Explain the principle of SLA (Stereolithography) technology and provide examples of its applications in medicine. • What are the main differences between FDM and SLS technologies in the context of medical applications? Bioprinting: • Describe the bioprinting process using the extrusion method and list its main applications in regenerative medicine. • What challenges arise in applying bioprinting to create functional organs? Nanotechnology: • Explain how nanoparticles can be used as drug carriers in targeted therapy. • List three examples of nanomaterials used in medical diagnostics and describe their functions. Smart Materials: • What are shape-memory materials? Provide an example of their application in medicine. • What are the advantages of using biodegradable materials in medical implants? Commercialization of Technologies: • Describe the main stages of the commercialization process for modern medical technologies. • What are the key regulations for the certification of medical devices in Europe?	
Work placement	Not applicable	

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