



Subject card

Subject name and code	Additive Techniques in Medical Engineering, PG_00064136						
Field of study	Mechanical and Medical Engineering						
Date of commencement of studies	October 2024		Academic year of realisation of subject		2026/2027		
Education level	first-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	3		Language of instruction		Polish		
Semester of study	5		ECTS credits		4.0		
Learning profile	general academic profile		Assessment form		exam		
Conducting unit	Division of Biomaterials Technology -> Institute of Manufacturing and Materials Technology -> Faculty of Mechanical Engineering and Ship Technology -> Faculties of Gdańsk University of Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		dr inż. Magda Rościszewska				
	Teachers		dr inż. Magda Rościszewska mgr inż. Balbina Makurat-Kasprolewicz				
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	30.0	15.0	0.0	60
	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	60		5.0		35.0	100
Subject objectives	To develop the ability to design, manufacture, and evaluate structures intended for applications in medical engineering using additive manufacturing techniques, based on knowledge of material properties, the principles and limitations of 3D printing technologies, and methods for testing and selecting manufacturing process parameters.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K6_U03] is able to use information and communication skills or research techniques to solve typical engineering tasks related to design, production and manufacturing of materials or machine components	Able to use IT tools and research techniques appropriate for the design, manufacturing, and evaluation of the properties of medical devices produced using additive manufacturing techniques.	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools [SU5] Assessment of ability to present the results of task
	[K6_U02] is able to prepare design and technology documentations, present results of engineering tasks in both Polish and a foreign language	Able to prepare design and technological documentation for a medical device manufactured using additive manufacturing techniques and present the results of a completed engineering task in Polish and/or a foreign language.	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools [SU5] Assessment of ability to present the results of task
	[K6_W02] has knowledge of structure, properties, and testing methods of construction materials or knowledge of materials and selected technologies in biomedical engineering	Knows and understands the structure, properties, and testing methods of materials used in additive manufacturing, as well as the principles of selected additive manufacturing technologies in the context of their applications in medical engineering.	[SW1] Assessment of factual knowledge [SW2] Assessment of knowledge contained in presentation [SW3] Assessment of knowledge contained in written work and projects
Subject contents	Course content – lecture Introduction to additive manufacturing and its applications in medicine, with particular emphasis on personalized medical devices, anatomical models, implants, surgical instruments, and bioprinting. Classification and operating principles of selected 3D printing technologies, including Binder Jetting, Material Jetting (PolyJet), Directed Energy Deposition, Sheet Lamination, and Direct Ink Writing (DIW). Materials used in 3D printing for medical applications: polymers, photopolymer resins, hydrogels, metals, ceramics, composites, and materials used in bioprinting. Stages of medical device design: identification of needs, definition of requirements, concept development, data acquisition, CAD modeling, design for additive manufacturing (DfAM), selection of materials and technologies, prototyping, testing, and iterative improvement of the solution. Limitations and challenges of additive manufacturing technologies, including accuracy, repeatability, costs, and basic certification issues. Examples of clinical applications and current research and development directions in medical 3D printing.		
	Course content – laboratory Introduction to occupational health and safety rules, the properties of sodium alginate and gelatin, and the preparation of solutions for testing. Selection of alginate concentration based on syringe-based tests and viscosity measurements using Stokes' method. Evaluation of the suitability of selected formulations for 3D printing and selection of printing parameters, including pressure and printing speed. Investigation of the effects of calcium chloride (CaCl_2) concentration and crosslinking time on the resulting structures. Design of simple three-dimensional structures (scaffolds), taking into account their geometry and design parameters. Fabrication of the designed 3D structures using the selected material formulation and printing and crosslinking parameters. Analysis of the results, preparation of laboratory reports, and presentation of the procedures and outcomes of the experiments.		
	Course content – project Development of a concept for an original solution using additive manufacturing techniques, based on a literature review and the selection of a material (alginate or gelatin). Preparation of the selected material formulation and performance of syringe-based tests. Production of preliminary 3D prints, analysis of the results, and modification of the proposed solution and process parameters. Fabrication of the final 3D structure. Preparation of a project report in the form of a scientific paper, documenting the project objectives, implementation process, results, and conclusions.		
Prerequisites and co-requisites	Basic knowledge of materials science, chemistry, and engineering design, as well as basic computer skills. Willingness to comply with occupational health and safety rules during laboratory classes.		

Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Assessment of knowledge of material preparation, testing methods, and process parameters based on laboratory entry quizzes	60.0%	24.0%
	Assessment of the presentation of laboratory procedures and experimental results	60.0%	6.0%
	Assessment of the development of an original solution using additive manufacturing techniques and the preparation of design and technological documentation in the form of a scientific article.	60.0%	10.0%
	Assessment of knowledge of materials, additive manufacturing technologies, and their medical applications based on a lecture test	60.0%	60.0%
Recommended reading	Basic literature	1. Gibson I., Rosen D., Stucker B., Khorasani M., Additive Manufacturing Technologies, wyd. 3, Springer, 2021. DOI: 10.1007/978-3-030-56127-7 2. Dixit A., Kumar A., Pathak D. K. (red.), Additive Manufacturing for Biomedical Applications: Recent Trends and Challenges, Springer, 2024. DOI: 10.1007/978-981-97-5456-4 3. Lee S. C., Gillispie G., Lee S. J., Physical and Chemical Factors Influencing the Printability of Hydrogel-based Extrusion Bioinks, „Chemical Reviews”, 2020, 120(19), 10797–10849. DOI: 10.1021/acs.chemrev.0c00015	
	Supplementary literature		
	eResources addresses		

Example issues/ example questions/ tasks being completed	Lecture
	1. Explain the principle of additive manufacturing and provide examples of its applications in medicine.
	2. Discuss the importance of personalized medical devices and the use of 3D printing to manufacture anatomical models, implants, and surgical instruments.
	3. Describe the operating principles of selected 3D printing technologies, including Binder Jetting, Material Jetting (PolyJet), Directed Energy Deposition, Sheet Lamination, and Direct Ink Writing (DIW).
	4. Compare the properties and applications of selected polymers, hydrogels, metals, ceramics, and composites used in 3D printing for medical applications.
	5. Outline the stages of medical device design, from identifying a need to testing and improving the solution.
	6. Explain the importance of design for additive manufacturing (DfAM) and the selection of materials and technologies for the intended application.
	7. Discuss the limitations of additive manufacturing technologies related to accuracy, repeatability, costs, and medical device certification.
	Laboratory
	1. Prepare sodium alginate solutions at specified concentrations and perform syringe-based tests.
	2. Measure viscosity using Stokes' method and select formulations for further investigation based on the results obtained.
	3. Evaluate the suitability of selected formulations for 3D printing and select the printing pressure and speed.
	4. Investigate the effects of CaCl_2 concentration and crosslinking time on the resulting structures.
	5. Design simple three-dimensional structures (scaffolds) and fabricate them using the selected process parameters.
	6. Prepare laboratory reports and a group presentation covering the experimental procedures, results obtained, and conclusions.
	Project
	1. Develop a concept for an original solution using additive manufacturing techniques based on a literature review.
	2. Select a material, prepare a formulation, and perform syringe-based tests.
	3. Produce preliminary 3D prints, analyze the results, and make justified modifications to the solution or process parameters.
	4. Fabricate the final 3D structure and evaluate the outcome against the project objectives.
	5. Prepare design and technological documentation in the form of a scientific article, presenting the project objectives, implementation process, results, and conclusions.

Practical activities within the subject	Not applicable
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