COURSE SPECIFICATION

Course code	full-time programme:	**M#2-S2-ME-208**
	part-time programme:	
Course title in Polish	**Badania zaawansowanych metod druku 3D**	
Course title in English	**Materials Characterization in Advanced 3D Printing**	
Valid from (academic year)	**2024/2025**	

GENERAL INFORMATION

Programme of study	**MECHANICAL ENGINEERING**
Level of qualification	**second-cycle**
Type of education	**academic**
Mode of study	**full-time programme**
Specialism	**all**
Department responsible	**Department of Metrology and Modern Manufacturing**
Course leader	**dr hab. inż. Tomasz Kozior, prof. PŚk**
Approved by	**dr hab. Jakub Takosoglu, prof. PŚk, Dean of the Faculty of Mechatronics and Mechanical Engineering**

COURSE OVERVIEW

Course type		**programme-specific**
Course status		**compulsory**
Language of instruction		**English**
Semester of delivery	full-time programme	**Semester II**
	part-time programme	**Semester II**
Pre-requisites		
Examination required (YES/NO)		**NO**
ECTS value		**2**

Mode of instruction		**lecture**	**class**	**laboratory**	**project**	**seminar**
No. of hours per semester	full-time programme	**15**		**30**		
	part-time programme					

LEARNING OUTCOMES

Category of outcome	Outcome code	Course learning outcomes	Corresponding programme outcome code
Knowledge	W01	Student has an in-depth and structured knowledge of the phenomena occurring in mechanical machines and devices, in particular 3D printers, in terms of performing mechanical property tests.	**MiBM2_W02**
	W02	Student has a structured and theoretically deepened knowledge in the field of engineering tasks related to mechanics and mechanical engineering, broadly understood design including prototyping, knows the main development trends in these fields in particular in the area of 3D printing.	**MiBM2_W03**
	W03	Student has a detailed and in-depth knowledge of the technology of manufacturing and machining of machine parts, in particular of incremental technologies, issues of rapid prototyping, also has a structured and in-depth knowledge of the construction of various types of systems for machining and shaping materials.	**MiBM2_W05**
	W04	Student has in-depth knowledge in the area of measurement of geometrical, mechanical, operational or strength parameters in particular in the area of 3D printing.	**MiBM2_W08**
	W05	Student has solid knowledge necessary to understand economic, legal, social, ethical, ecological and other non-technical conditions of professional activity in the area of technological process of manufacturing models using 3D printing technology. Knows the fundamental dilemmas of modern civilization.	**MiBM2_W14**
Skills	U01	Student is able to use knowledge from the area of basic sciences to formulate and solve complex engineering tasks in various areas of mechanics and machine construction at the design, construction, materials selection, manufacturing, prototyping and testing stages. Is able to evaluate, critically analyze and synthesize obtained results and express opinions and comments.	**MiBM2_U01**
	U02	Student is able to design the technological process of typical machine parts in the area of mechanics and machine construction and select appropriate machines and devices for this purpose.	**MiBM2_U07** **MiBM2_U13**
	U03	Student is able to perform measurements of various types of quantities and parameters related to the manufacturing process, testing and operation of mechanical parts and systems, is able to interpret the obtained results, analyze measurement uncertainty and develop conclusions.	**MiBM2_U10**
	U04	Student is able to select appropriate engineering materials, manufacturing technologies and technological parameters to ensure the appropriate quality of manufactured models and the correct operation of a machine or system in various areas of mechanics and machine construction, taking into account multi-variant solutions if necessary.	**MiBM2_U12**

	U05	Student is able to recognise the complex interrelationship of engineering decisions with the non-technical area including recognition of environmental, economic, legal and sustainable design aspects with safety and accessibility criteria in accordance with applicable requirements and standards.	**MiBM2_U14**
Competence	K01	Student is aware of the need to independently supplement and expand knowledge in the field of mechanics and machine construction. Is ready to critically evaluate the knowledge they possess, the importance of knowledge in solving cognitive and practical problems, and the need to acquire new information both from literature and from experts in the field of mechanics and machine construction. Understands the need and knows the possibilities of continuous improvement (third-cycle studies, postgraduate studies, courses) aimed at improving professional, personal and social competences.	**MiBM2_K01**
	K02	Student is aware of the importance of and understands the non-technical aspects and effects of engineering activities, including their impact on the safety of other people and the impact on the environment and the responsibilities associated with these issues.	**MiBM2_K02**
	K03	Student is ready to responsibly perform professional roles related to the field of study of mechanics and machine construction, adhere to ethical principles and work to ensure compliance with these principles, taking into account changing social needs, cares about the achievements, ethos and traditions of the profession. Adheres to the principles of professional ethics and takes action to ensure their compliance.	**MiBM2_K05**

COURSE CONTENT

Mode of instruction	Topics covered
lecture	Familiarizing students with advanced 3D printing technologies based on plastics and metals used in industrial and research practice, both in the area of prototyping and production series production. Introduction to the safe use of the above-mentioned 3D printing methods in the aspect of modern engineering materials based on current standards and literaturę. Discussion of research on the assessment of selected properties/quality features of models manufactured using 3D printing technology, as well as an introduction to estimating the impact of technological parameters on the quality of manufactured models. Introduction to the process of planning, conduct and analyzing research results based on research literature and international standards. Discussion of standards currently used in 3D printing, with particular focus on the industrial and research aspect. Methods of presenting research results, taking into account the standard deviation and uncertainty of measurements. Discussion of ecological and ethical problems in the aspect of using 3D printing, disposal of materials and recycling possibilities.

laboratory	Conducting laboratory assignments covering the analysis of the impact of selected technological parameters of the 3D printing process on selected properties of the manufactured models. Conducting laboratory exercises covering the analysis of rheological properties (relaxation and creep), tensile, compressive and bending strength, assessment of the surface texture, microscopic assessment of the surface, assessment of stiffness. Performing introductory to advanced 3D printing technologies such as selective laser sintering - SLS and Photo-curing of liquid polymer resins - PJM using 3D printers in the laboratory. Use of standard sample models, models with a cellular structure and thin-walled models. Conducting an extended evaluation of digital files used in 3D printing with a focus on the quality of the manufactured models. Presentation of test results using statistical assessment (standard deviation, measurement uncertainty).

ASSESSMENT METHODS

Outcome code	Methods of assessment					
	Oral examination	Written examination	Test	Project	Report	Other
W01			X			
W02			X			
W03			X			
W04			X			
W05			X			
U01					X	
U02					X	
U03					X	
U04					X	
U05					X	
K01						X
K02						X
K03						X

ASSESSMENT TYPE AND CRITERIA

Mode of instruction	Assessment type	Assessment criteria
lecture	non-examination assessment	Passing the colloquium with at least 50%.
laboratory	non-examination assessment	Preparing and passing of all laboratories reports with a minimum of 50% each.

OVERALL STUDENT WORKLOAD

ECTS weighting												
No.	Activity type	Student workload										Unit
		full-time programme					part-time programme					
1.	Scheduled contact hours	L	C	Lb	P	S	L	C	Lb	P	S	h
		15		**30**								
2.	Other contact hours (office hours, examination)	**2**		**2**								h

3.	**Total number of contact hours**	**49**		h
4.	**Number of ECTS credits for contact hours**	**1,6**		ECTS
5.	**Number of independent study hours**	**11**		h
6.	**Number of ECTS credits for independent study hours**	**0,4**		ECTS
7.	**Number of practical hours**	**40**		h
8.	**Number of ECTS credits for practical hours**	**1,3**		ECTS
9.	**Total study time**	**60**		h
10.	**ECTS credits for the course** *1 ECTS credit = 25-30 hours of study time*	**2**		ECTS

READING LIST

1. Kozior T., Bochnia J.: Fundamentals of Rapid Prototyping, 3D printing, FDM/FFF technology, Kielce University of Technology Publisher, Kielce 2024/2025.
2. Chua., Chee Kai.: 3D printing and additive manufacturing: principles and applications, the 5th edition of rapid prototyping: principles and application, World Scientific, 2017.
3. Bochnia J.: Wybrane właściwości fizyczne materiałów kształtowanych technologiami przyrostowymi, Wydawnictwo Politechniki Świętokrzyskiej, Kielce 2018.
4. Budzik G., Siemiński P.: Techniki przyrostowe. Druk 3D. Drukarki 3D, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2015.
5. Budzik G., Woźniak J., Przeszłowski Ł.: Druk 3D jako element przemysłu przyszłości. Analiza rynku i tendencje rozwoju., Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów 2022.

International Standards

1. PN-EN ISO/ASTM 52900: Additive manufacturing — General principles — Fundamentals and vocabulary, 2021.
2. PN-EN ISO/ASTM 52901: Additive manufacturing — General principles — Requirements for purchased AM parts, 2018.
3. ISO 3384-1: Rubber, vulcanized or thermoplastic — Determination of stress relaxation in compression — Part 1: Testing at constant temperaturę, 2019.
4. ISO 527-1:Plastics — Determination of tensile properties - Part 1: General principles, 2019.
5. ISO 178: Plastics — Determination of flexural properties, 2019.
6. ISO 604: Plastics — Determination of compressive properties, 2002.
7. ISO 899-1: Plastics — Determination of creep behaviour, Part 1: Tensile creep, 2017.