Lodz University of Technology

Study programme

Faculty:	Faculty of Chemistry
Major:	Technologies of Modern Functional Materials
Level of study:	second-cycle programme (magister)
Form of study:	full-time studies
Academic year:	2026/27

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Basic information

Name of the field of study:	Technologies of Modern Functional Materials
Level of study:	second-cycle programme (magister)
Study profile:	general academic
Form of studies:	full-time studies
Duration of studies (number of semesters):	3
The number of ECTS points required to complete studies:	90
Total number of hours of classes:	1175
The number of ECTS points a student obtains as part of classes conducted with the direct participation of academic teachers or other persons conducting classes:	47
Professional title awarded to graduates:	magister
ISCED code:	0531
Language of study:	polish

Assigning the course to the disciplines to which the learning outcomes relate

Discipline	Percentage share
Chemical science	60%
Material Engineering	40%

Learning outcomes (in relation to the PQF)

No.	Learning outcome code	Learning Outcome Content	Reference to the universal characteristics of the first level of PRK	Reference to the second-level characteristics of the PRK, taking into account the second-level characteristics enabling the acquisition of engineering competences
1	**2TNM1**	Knows and understands in depth issues related to devices, manufacturing technologies and methods of testing functional materials, useful for formulating and solving complex tasks in the field of chemical science and material engineering.	P7U_W	P7S_WG
2	**2TNM2**	Knows and understands in depth the structure and properties of functional materials, describes chemical reactions and physical phenomena occurring on their surface.	P7U_W	P7S_WG
3	**2TNM3**	Knows and understands development trends in the disciplines of chemical sciences and materials engineering and discusses the impact of the development of functional materials technology on the progress of civilization.	P7U_W	P7S_WG, P7S_WK
4	**2TNM4**	Knows and understands the basics of management and running a business, as well as the principles of industrial property protection and copyright, which are necessary to understand the non-technical conditions of professional activity.	P7U_W	P7S_WK
5	**2TNM5**	Is able to identify complex and unusual problems related to the design, technology and devices for the production of functional materials and the construction of devices using these materials.	P7U_U	P7S_UW
6	**2TNM6**	Formulates hypotheses and solves problems in the field of design and technology of manufacturing functional materials, including critical analysis of existing technical solutions and devices and proposing their improvements, also taking into account non-technical aspects.	P7U_U	P7S_UW
7	**2TNM7**	Integrates and interprets information obtained from various sources, formulates conclusions and justifies opinions, and communicates with various audiences, also in a foreign language (at the B2 + ESOKJ level of proficiency).	P7U_U	P7S_UK
8	**2TNM8**	Is able to cooperate and work in a group and take a leading role in a team, plan and pursue his own development and direct others in this regard.	P7U_U	P7S_UO, P7S_UU
9	**2TNM9**	Is ready to act with open-mindedness, creativity and entrepreneurship, also in the context of non-technical and social aspects.	P7U_K	P7S_KK, P7S_KO, P7S_KR

Matrix of course modules in relation to learning outcomes and curriculum content

No.	Course name	Program content	2TNM1	2TNM2	2TNM3	2TNM4	2TNM5	2TNM6	2TNM7	2TNM8	2TNM9
1	Competence Project I	Teamwork methodology: team formation, risk analysis, planning, and reporting. Defining research problems and applying methods such as PBL, Design Thinking, SWOT, and Case Study. Solution design: Gantt chart, prototyping, testing, and reporting results.									
2	Modern Metal and Ceramic Engineering Materials	Modern metal and ceramic engineering materials – classification, properties, and manufacturing methods. Computer-aided materials selection in materials engineering.		x	x		x				
3	Engineering Polymer Materials	The relationship between the structure of polymers, their physical and chemical properties, and their functional properties, which are important for the use of polymeric materials as engineering materials.		x			x			x	
4	Modern Technologies and Equipment for Manufacturing and Modification of Materials	Technologies for manufacturing materials by sintering and coating technologies. Methods for volumetric and surface modification of materials. The structure and operating principles of processing equipment for manufacturing and modifying polymeric materials with specific functional properties.	x				x				
5	Functional Materials	Definition, characteristics, importance, and applications of various groups of functional materials. Components enabling the production of polymeric materials with various, precisely defined functionalities – principles of selection.			x			x			
6	Practical Problems of Patenting and Obtaining Research Funding	Preparation of patent applications and their filing procedures with the Polish Patent Office and the European Patent Office. Principles for obtaining and applying for EU funds.				x			x	x	x
7	Foreign Language for Specialist Purposes	Foreign language course at B2+ level; developing the ability to communicate effectively in speech and writing, using specialist terminology from the field of study.							x	x	
8	Competence Project II	Learning to solve technological problems related to the production of polymeric functional materials. Developing skills in solving real-world technological problems by solving case studies based on real-world issues from industry representatives.		x						x	x
9	Smart Coatings Technologies	Introduction to manufacturing and processing technologies, as well as the most important applications of smart coating materials.	x	x			x				
10	Advanced Vacuum Technologies	Technical vacuum, vacuum systems, and differences in processing at atmospheric and reduced pressure. Methods of thermal and thermo-chemical treatment, PVD, CVD, duplex processes, and plasma-assisted techniques. Technological surface layer, coatings, and requirements for material cores and surfaces.	x				x	x			
11	3D Printing Technology	Preparation for independent 3D printer operation and model preparation software. Learning 3D printing technologies (FDM/FFF, SLA, SLS, DMLS, BJ) and related materials. Familiarization with modeling applications and slicing software.	x					x	x		

No.	Course name	Program content	2TNM1	2TNM2	2TNM3	2TNM4	2TNM5	2TNM6	2TNM7	2TNM8	2TNM9
12	Specialized Methods of Materials Testing	Functional materials research methodology, including selected analytical, microscopic, and spectroscopic techniques, including methods for measuring thermal, mechanical, and rheological properties.	x					x	x		
13	Modern Technologies for Functional Materials Synthesis	Mechanisms and methods for conducting polymerization processes to obtain well-defined polymers with specific properties. Methods for modifying polymers to obtain materials with specific functionality.			x		x			x	
14	Technological Expertise	Analysis of real and simulated technological problems encountered in the processing of polymer materials, conducted in collaboration with industry. Recording and observation of real and fictional technological problems to acquire skills in solving similar cases in subsequent professional practice.						x		x	x
15	Commercialitazion in Practice	Fostering creativity and unconventional thinking. Gaining knowledge of entrepreneurship and practical business activities. Developing an innovative approach to project implementation.				x				x	x
16	Surface Topography of Materials - Importance, Advanced Shaping Methods, Applications	Methods for shaping the surface topography of materials. Methods for studying surface topography. Studies on the effect of surface topography on the adhesion of coatings and their selected properties.		x	x		x				
17	Plasma Technologies for the Needs of Medicine	Plasma techniques used to modify the surface of biomaterials. The effect of plasma modification on the surface properties of biomaterials. Application possibilities of individual technologies to achieve specific modification effects.		x	x		x				
18	2D Materials	Synthesis, structure, and properties of two-dimensional (2D) materials. Description of manufacturing, scalability, and new applications of 2D materials.		x	x		x				
19	Modern Technologies for Space Industry	Requirements for the properties of materials used in the space industry. Potential directions of development for industries related to the space industry. Modern techniques for manufacturing and processing light alloys and composites for space applications.		x	x		x				
20	Self-healing Polymers and Composites	Methods for manufacturing self-healing composites, self-healing mechanisms. Characterization and methods for testing the self-healing effect. Application of self-healing polymers and composites.		x	x		x				
21	Composite Shielding Materials Against High Energy Radiation	Effects of ionizing radiation on living organisms and materials. Detection of ionizing radiation. Materials for protection against ionizing radiation.		x	x		x				
22	Inorganic and Organic Functional Materials	Methods for obtaining and using inorganic functional materials. Organic functional materials. Functionalization and modulation of the properties of organic materials and the creation of organic-inorganic hybrid materials.		x	x		x				
23	Functional Dyes and Pigments	Preparation and use of functional dyes and pigments. The use of dyes and pigments in modern techniques.		x	x		x				
24	Diploma Seminar	Preparation for the diploma thesis - research and editing aspects. Preparation for the diploma exam - creating a final presentation, formulating answers to the committee's questions. Preparation for the competency exam, verifying the degree of achievement of key learning outcomes.	x		x						

No.	Course name	Program content	2TNM1	2TNM2	2TNM3	2TNM4	2TNM5	2TNM6	2TNM7	2TNM8	2TNM9
25	Final Project	Implementing appropriate research methodology: reviewing the literature and formulating hypotheses or specific work objectives, identifying specific tasks. Selecting methods and tools appropriate to solve the problem – conducting experiments. Analyzing and describing the obtained results.	x					x			

ECTS - subjects

No.	Course name	ECTS	Subjects in the field of humanities and social sciences	Elective subjects	Profile items	Classes in a foreign language
1	Competence Project I	5		5	5	
2	Modern Metal and Ceramic Engineering Materials	6			6	
3	Engineering Polymer Materials	5			5	
4	Modern Technologies and Equipment for Manufacturing and Modification of Materials	4			4	
5	Functional Materials	5			5	
6	Practical Problems of Patenting and Obtaining Research Funding	3	3			
7	Foreign Language for Specialist Purposes	2				
8	Competence Project II	5		5	5	
9	Smart Coatings Technologies	6			6	
10	Advanced Vacuum Technologies	6			6	
11	3D Printing Technology	3			3	
12	Specialized Methods of Materials Testing	6			6	
13	Modern Technologies for Functional Materials Synthesis	4			4	
14	Technological Expertise	2			2	
15	Commercialitazion in Practice	2	2			
16	Surface Topography of Materials - Importance, Advanced Shaping Methods, Applications	2		2		2
17	Plasma Technologies for the Needs of Medicine	2		2		2
18	2D Materials	2		2		2
19	Modern Technologies for Space Industry	2		2		2
20	Self-healing Polymers and Composites	2		2		2

No.	Course name	ECTS	Subjects in the field of humanities and social sciences	Elective subjects	Profile items	Classes in a foreign language
21	Composite Shielding Materials Against High Energy Radiation	2		2		2
22	Inorganic and Organic Functional Materials	2		2		2
23	Functional Dyes and Pigments	2		2		2
24	Diploma Seminar	2				
25	Final Project	20		20	20	

ECTS indicators

Name	Value
The total number of ECTS credits that a student must obtain through elective courses (amounting to no less than 30% of the total ECTS credits required to obtain the qualification corresponding to the given level of study)	34/90 (37.78%)
The total number of ECTS credits to be earned by a student through courses in the fields of humanities or social sciences	5
The total number of ECTS credits that a student must obtain from courses related to research conducted at the university, amounting to more than 50% of the total ECTS credits required to graduate from a given level of study	77/90 (85.56%)

Methods of verifying and assessing learning outcomes

Verifying the achieved learning outcomes requires the use of diverse forms of student assessment, appropriate to the categories of knowledge, skills, and social competences to which they relate. The selection of appropriate tools also depends on the specific nature of the subject and the form of teaching and is described in each case in the individual course cards. Achievement of the required learning outcomes is assessed through:

1. written assignments (exams, tests, reports, essays, projects, posters, thesis, etc.);
2. oral presentations (oral knowledge tests, public speaking, e.g., presentations, etc.);
3. practical and/or project tasks (team and individual);
4. observation and assessment of student activity during classes;
5. student self-assessment and peer assessment (especially in the case of team projects);
6. competency examination and diploma examination.

Assessment may be formative (partial, repeated throughout the course) and/or summative (final grade). The final assessment result is given on the currently applicable grading scale. During the first class of the subject, the course leader or lecturer is obliged to discuss the course card and to formulate and document the methods of verification and conditions for conducting tests to ensure that learning outcomes are achieved.

Professional internships

Not applicable.

Characteristics of the course

Graduate profile

Graduates of the second-cycle program in Technologies of modern functional materials possess in-depth knowledge and skills in the design, modern synthesis methods, devices, and technologies for processing and modifying advanced engineering materials with various functionalities, as well as their applications in various industries. They are skilled at selecting appropriate research techniques and applying them to study the structure, morphology, and properties of functional materials, including intelligent and functional materials in the field of polymers, composites, laminates, porous materials, metals, ceramics, dyes, and materials with specific surface properties. They are characterized by the ability to independently solve unique problems related to the design and adaptation of new or improved devices, as well as technologies for manufacturing and modifying functional materials. They also have the ability to work in a team and communicate with specialists from various disciplines. They demonstrate creativity and entrepreneurship in their work, including non-technical and social aspects.

The relationship between the field of study and the university's strategy

The study program Technologies of modern functional materials is consistent with the Lodz University of Technology Strategy for 2025–2030 (Resolution No. 39/2024 of the Lodz University of Technology Senate) and pursues its goals in the areas of INNOVATION, SCIENCE, EDUCATION, TALENTS, and IMPACT.

This program supports the development of innovation and technology transfer through education in the design, synthesis, modification, characterization, and applications of modern functional materials, as well as project-based classes in collaboration with industry. Students solve real-world technological problems in enterprises, which fosters the development of R&D research with high application potential, long-term university-business collaboration, and the commercialization of research results.

In the scientific field, the program strengthens interdisciplinary research combining chemistry, materials engineering, chemical technology, and environmental and industrial issues. The program is based on current research directions conducted at Lodz University of Technology, and its implementation promotes research with socially and economically beneficial effects and builds the international recognition of the university's scientific community.

In terms of education, the program responds to the needs of the labor market by offering a modern and interdisciplinary curriculum, delivered by research-oriented academics. Innovative teaching methods, such as PBL, RBL, case teaching, design thinking, and flipped education, are widely used in the teaching process, as well as classes conducted in collaboration with industry, enabling students to gain practical experience outside of the university.

The study program supports talent attraction by offering an attractive career path for students interested in advanced materials technologies and creating opportunities to continue their academic careers through doctoral studies. This contributes to the development of interdisciplinary research staff.

In terms of its impact on the socio-economic environment, the program implements the concept of lifelong learning and actively collaborates with businesses and research and development institutions. The study program responds to the needs of the modern labor market and contributes to the development of the regional and national economy by educating highly qualified specialists and conducting research that addresses real-world technological, environmental, and social problems.

Educational objectives and employment and continuing education opportunities

The aim of this study program is to prepare graduates for professional careers in the field of manufacturing technologies and characterization of a wide range of functional materials used in many industries. The educational objectives include acquiring skills in designing technologies for the production of modern functional materials, including intelligent and functional materials in the areas of polymers, composites, laminates, porous materials, metals, ceramics, and dyes, such as self-healing materials, shape memory materials, conductive composites, magnetorheological, photoluminescent, fluoroluminescent, photochromic, and thermochromic materials, as well as materials manufactured and surface-modified using the latest technologies (including vacuum, duplex, and 3D printing), in the form of solid materials, powders, coatings, and 2D materials. Additionally, materials with specific surface properties, such as hard and superhard materials, heat-resistant materials, highly biocompatible and bioactive materials, low-friction and wear-resistant materials, thermal barriers, radiation reflectors, optical materials, catalytic materials, anti-adhesive materials, materials that enhance corrosion resistance, and materials with shaped surface topography, are particularly well-prepared for the comprehensive characterization of functional materials and their application in specific construction solutions. Based on their accumulated knowledge,

graduates are ready to undertake design tasks and solve research and technological problems related to the application of modern, advanced technologies for the production and characterization of functional engineering materials for all branches of science and technology that create a demand for design solutions that enhance reliability, safety, and comfort.

The educational objectives also include developing independent problem-solving skills, teamwork skills, and the ability to communicate with specialists from various disciplines. The defined learning outcomes are designed to equip students with the ability to utilize interdisciplinary knowledge and design and adapt new or modify existing technologies and research and measurement methods. Graduates acquire a high level of skill in collecting, processing, and communicating scientific and technical information, as well as identifying, properly defining, and analyzing problems and developing solutions.

Graduates of this study program have broad career prospects in companies producing, processing, or using functional engineering materials, including the chemical, packaging, plastics, paints and varnishes, machinery, automotive, construction, defense, shipbuilding, and aerospace industries. Thanks to their knowledge of the production and design of intelligent materials used in demanding structural components and safety systems, graduates can also expect employment in industries with the highest current dynamics, including energy, transportation, electronics, medicine, dentistry, and implantology. They are well-prepared for employment in scientific, research, development, and design institutions, laboratories, and research institutes. Graduates are prepared to undertake third-cycle studies and work in interdisciplinary national and international teams.

Description of the process and outcome of consultations on the proposed study program with the socio-economic environment

Consultations regarding the study program were conducted with representatives of socio-economic stakeholders – representatives of manufacturing companies from various industries, including Hutchinson S.A. in Łódź, BSG Sp. z o.o. in Zgierz, and CDM Sp. z o.o. in Ksawerów. These discussions revealed market demand for personnel with knowledge, professional competencies, and skills in the design and selection of manufacturing technologies for a wide range of functional materials, as well as their characterization. Letters of intent were obtained, in which representatives of manufacturing plants recommended that the professional competencies acquired by graduates of this program are crucial for modern industry, especially in areas related to the implementation of new technologies, process optimization, and the development of advanced products. The study program also received a positive opinion from the Business Council operating at the Faculty of Chemistry, Lodz University of Technology.

Description of competencies expected from a candidate applying for admission to studies

Completed engineering studies (level 6).

The unit organizing education

Faculty of Chemistry

Education program

Semester 1

Course	Number of hours	ECTS points	Form of verification	Obligatory
Competence Project I	Project work: 30	5	Graded assignment	Obligatory subjects to choose from
Modern Metal and Ceramic Engineering Materials	Laboratory classes: 30 Project work: 15 Lecture: 45	6	Exam	Obligatory
Engineering Polymer Materials	Laboratory classes: 30 Lecture: 30	5	Exam	Obligatory
Modern Technologies and Equipment for Manufacturing and Modification of Materials	Project work: 5 Lecture: 30	4	Graded assignment	Obligatory
Functional Materials	Seminar: 10 Project work: 15 Lecture: 40	5	Graded assignment	Obligatory
Practical Problems of Patenting and Obtaining Research Funding	Project work: 20	3	Graded assignment	Obligatory
Foreign Language for Specialist Purposes	Tutorials: 45	2	Graded assignment	Obligatory
Sum	**345**	**30**		

Semester 2

Course	Number of hours	ECTS points	Form of verification	Obligatory
Competence Project II	Project work: 30	5	Graded assignment	Obligatory subjects to choose from
Smart Coatings Technologies	Laboratory classes: 45 Lecture: 30	6	Graded assignment	Obligatory

Course	Number of hours	ECTS points	Form of verification	Obligatory
Advanced Vacuum Technologies	Laboratory classes: 45 Lecture: 30	6	Graded assignment	Obligatory
3D Printing Technology	Laboratory classes: 30 Lecture: 20	3	Graded assignment	Obligatory
Specialized Methods of Materials Testing	Laboratory classes: 45 Lecture: 30	6	Exam	Obligatory
Modern Technologies for Functional Materials Synthesis	Laboratory classes: 30 Lecture: 15	4	Exam	Obligatory
Sum	**350**	**30**		

Semester 3

Course	Number of hours	ECTS points	Form of verification	Obligatory
Technological Expertise	Project work: 20	2	Graded assignment	Obligatory
Commercialitazion in Practice	Project work: 5 Lecture: 15	2	Graded assignment	Obligatory
Elective Courses in Foreign Languages I		2	Graded assignment	Obligatory group
The student chooses 1 course from the group.				
Surface Topography of Materials - Importance, Advanced Shaping Methods, Applications	Laboratory classes: 15 Lecture: 15	2	Graded assignment	Optional
Plasma Technologies for the Needs of Medicine	Laboratory classes: 15 Lecture: 15	2	Graded assignment	Optional
2D Materials	Laboratory classes: 15 Lecture: 15	2	Graded assignment	Optional
Modern Technologies for Space Industry	Laboratory classes: 15 Lecture: 15	2	Graded assignment	Optional
Elective Courses in Foreign Languages II		2	Graded assignment	Obligatory group

Course	Number of hours	ECTS points	Form of verification	Obligatory
The student chooses 1 course from the group.				
Self-healing Polymers and Composites	Laboratory classes: 15 Lecture: 15	2	Graded assignment	Optional
Composite Shielding Materials Against High Energy Radiation	Laboratory classes: 15 Lecture: 15	2	Graded assignment	Optional
Inorganic and Organic Functional Materials	Laboratory classes: 15 Lecture: 15	2	Graded assignment	Optional
Functional Dyes and Pigments	Laboratory classes: 15 Lecture: 15	2	Graded assignment	Optional
Diploma Seminar	Seminar: 30	2	Graded assignment + exam	Obligatory
Final Project	Diploma Thesis: 0	20	Pass	Obligatory subjects to choose from
Sum	**130**	**30**		