Attachement no. 1 to Programme of Education

LEARNING OUTCOMES FOR THE FIELD OF STUDY

(Assumed educational effects)

Faculty: Mechanical and Power Engineering

Field of study: Mechanical Engineering and Machine Building (MBM)

Level of study: II (post-graduate)

The area of study:

Field of study Mechanical Engineering and Machine Building belongs to the domain of technical sciences and is related to such majors as Energy, Environmental Engineering, Electrical Engineering, Process Engineering and Aerospace Engineering.

Concept of the post-graduate studies and their relation to the undergraduate studies

An applicant for the admission to the Master's degree in Mechanical Engineering and Machine Building must have undergraduate degree and possess competencies to continue education at post-graduate level in this field of study. The candidate should have in particular the following abilities:

- knowledge of mathematics, physics and chemistry that enable understanding of the fundamentals of mechanics, material sciences and principles of machinery construction,
- knowledge of mechanics, strength of materials and the foundations of machine construction that enable understanding and design of the basic machine elements,
- ability to use analytical methods, simulation and experiment to formulate and solve engineering problems,
- knowledge on the flows of fluids, including all thermal processes,
- knowledge of 2D and 3D CAD design,
- ability to communicate in English, document and present experimental results, document and present the outcomes of a project,
- knowledge on thermal processes such as refrigeration, cryogenics, and incineration.

The candidate who on completion of undergraduate studies or other forms of education did not obtain the above competencies, may take a second degree in Mechanical Engineering and Machine Building, only if competence deficiencies can be completed by crediting classes that are worth no more than 30 ECTS points.

The reference to the learning outcomes for post-graduate level education in the area corresponding to the domain of technical sciences

Because a person who studies towards Master's degree in Mechanical Engineering and Machine Building obtained necessary expertise to undertake them on the completion of the undergraduate studies or – in the absence of some of the required competencies – can complement insufficiencies by implementation schedule of no more than 30 ECTS credits, the description of the learning outcomes for post-graduate studies does not necessarily refer to all the learning outcomes listed in the description of qualifications of the Master's degree in the field of study corresponding to given area of technical sciences (post-graduate level description includes combined effects of education achieved at both the undergraduate and post-graduate level of education).

Description of learning outcomes for Master's degree in Mechanical Engineering and Machine Building does not relate to the learning outcomes listed in the description of qualifications for Master's degree in the field of education corresponding to the domain of technical sciences: T2A_W10.

A graduate of the post-graduate studies must have the competencies defined by below listed learning outcomes. This does not mean, however, that all of these effects have to be achieved from the implementation of post-graduate studies program; a part of it can be obtained at the undergraduate level and - to a limited extent - as a result of informal learning.

Explanation of symbols:

K – learning outcomes for the field of study
S – learning outcomes for specialization
W – category of knowledge
U – category of skill
K (after the underscore) – category of social competencies
T – the area of study in the field of technical sciences
2 – post-graduate studies,
A – general profile

Learning outcome for post-graduate studies in the field of study: MBM	**DESCRIPTION OF THE MAIN LEARNING OUTCOMES** **After completion of the post-graduate studies in the field of Mechanics and Machine Design, the graduate:**	**Reference to learning outcomes for the area of technical sciences (T)**
	KNOWLEDGE	
K2MBM_W01	has structured, theoretically founded knowledge of the theory and application of microprocessor electronics to control electromechanical and pneumatic systems; distinguishes microcontrollers and microprocessors and explains principles of their programming and coupling to the components of mechatronic systems that are used in modern industrial machinery and power plants	T2A_W03
K2MBM_W02	has extended knowledge on shaping of the structure of modern engineering materials; describes phase equilibrium systems and phase transitions; can list selection principles of structural materials and their use in modern machine construction	T2A_W01 T2A_W03 T2A_W05
K2MBM_W03	has knowledge on mathematical description of the dynamics of mechanical systems represented by a finite number of material points; understands variation principles, invariants integral and the issues of small vibrations; recognizes canonical transformations and Hamilton-Jacobi equation; distinguishes stable and unstable equilibrium in mechanical systems and describes systems using cyclic coordinates	T2A_W01 T2A_W02 T2A_W04
K2MBM_W04	has knowledge of the structure of multidimensional real space and activities in this space; knows the theoretical basis of dimensional analysis as well as the rules for its use in the construction of mathematical models and moving the scale; understands the nature of optimization problems and the operation of certain optimization algorithms for functions of	T2A_W01 T2A_W03 T2A_W07

	one and several variables	
K2MBM_W05	knows basic tools for failure analysis; has basic understanding of the causes and consequences of failures in machinery	T2A_W03 T2A_W06
K2MBM_W06	has knowledge of basic production processes and the engineering platform that integrates business activities (CIM) from concept, through the design processes, production planning, manufacturing, resource management and recycling	T2A_W03 T2A_W06
K2MBM_W07	has knowledge needed to understand the social, economic, legal and other non-technical considerations of engineering activities	T2A_W08 T2A_W09
K2MBM_W08	knowledgeable about processes of business management	T2A_W09 T2A_W11
	achieves results in the category KNOWLEDGE for one of the following specializations: • Process Systems Engineering (IAP) – Appendix 1 • Engineering of Aviation (ILO) - Appendix 2 • Low Temperature Engineering (INN) -Appendix 3 • Refrigeration and Cryogenics (RAC) – Appendix 4 • Engineering Machines and Devices (MUE) – Appendix 5	
SKILLS		
K2MBM_U01	can build mechatronic systems that base on programmable controllers and incorporate electric and electro-pneumatic actuators; can write and run programs for programmable controllers using ladder language, is able to create and test programs with microcontroller development kits; can couple microcontrollers with the elements of mechatronic system	T2A_U08 T2A_U12
K2MBM_U02	is able to prepare samples of construction materials for testing, perform examinations and use results to identify characteristics and qualities of modern construction materials	T2A_U08 T2A_U18
K2MBM_U03	can build mathematical and physical models of processes; knows how to formulate objective functions and set up constraints in engineering optimization problems; is able to use numerical optimization methods to determine model parameters and the optimal process conditions	T2A_U07 T2A_U09 T2A_U10 T2A_U11 T2A_U16
K2MBM_U04	can perform deductive process directed at finding the cause of failure of the machine on the basis of failure reports and other sources of knowledge	T2A_U01 T2A_U10 T2A_U11 T2A_U13 T2A_U15
K2MBM_U05	can carry out engineering activities, ranging from initial design, through the stage of manufacturing process simulation, using integrated engineering environment such as CATIA.	T2A_U07 T2A_U09 T2A_U10 T2A_U17 T2A_U19
K2MBM_U06	has the ability to perform oral presentations on specific issues in the field of studied engineering discipline	T2A_U04 T2A_U05
K2MBM_U07	is able to prepare coherent report on the carried out work	T2A_U03 T2A_U05
K2MBM_U08	has language skills in the discipline "design and operation of	T2A_U02

	machines," according to the requirements for level B2 of the European Framework of Languages	T2A_U06
K2MBM_U09	has language skills in the discipline "design and operation of machines," according to the requirements for level A1 and A2 of the European Framework of Languages	T2A_U02
	achieves results in the category SKILLS for one of the following specializations: • Process Systems Engineering (IAP) – Appendix 1 • Engineering of Aviation (ILO) - Appendix 2 • Low Temperature Engineering (INN) -Appendix 3 • Refrigeration and Cryogenics (RAC) – Appendix 4 • Engineering Machines and Devices (MUE) – Appendix 5	
SOCIAL COMPETENCIES		
K2MBM_K01	understands the need to improve professional, personal and social skills; identifies and resolves dilemmas associated with his profession	T1A_K01 T1A_K05
K2MBM_K02	is aware of the importance of non-technical aspects and impacts of social engineering and the role of university graduates	T1A_K02 T1A_K07
K2MBM_K03	is able to work in a group and assume different roles	T2A_K03
K2MBM_K04	can properly identify priorities for implementation of self-defined or appointed tasks	T2A_K04
K2MBM_K05	is able to think and act in entrepreneurial manner	T2A_K06

Appendix 4

LEARNING OUTCOMES FOR SPECIALIZATION

Faculty: Mechanical and Power Engineering
Field of study: Mechanical Engineering and Machine Building (MBM)
Level of study: II (post-graduate)
Specialization: REFRIGERATION AND CRYOGENICS (RAC)

Learning outcome for post-graduate studies in specialization: RAC	DESCRIPTION OF THE MAIN LEARNING OUTCOMES After completion of the post-graduate studies in the field of Mechanics and Machine Design and specialization Refrigeration and Cryogenics, the graduate:	Reference to learning outcomes for the area of technical sciences (T)
	KNOWLEDGE	
S2RAC_W01	has knowledge of the thermodynamic and physical basis of refrigeration, cryogenics and low temperature physics, distinguishes and characterizes the basic processes used in refrigeration and cryogenics, and has knowledge of the thermodynamics of superconductivity, thermal stability and heat transfer at low temperatures	T2A_W01 T2A_W03
S2RAC_W02	has knowledge of the thermodynamic basics compressor refrigeration systems; distinguishes and describes the construction of compressor refrigeration, characterized and selected components of refrigeration systems used in refrigeration compressor for industrial, commercial and domestic	T2A_W04 T2A_W05
S2RAC_W03	has knowledge on refrigerants and coolants and their role in refrigeration, distinguishes and characterizes natural and synthetic refrigerants	T2A_W04 T2A_W05
S2RAC_W04	has knowledge of the theoretical basis of heat pumps and methods of using low temperature heat sources in air conditioning systems and heating systems	T2A_W04 T2A_W05
S2RAC_W05	has knowledge of air conditioning technology, distinguishes and describes the types of air conditioners and fans used in air-conditioning and ventilation	T2A_W04 T2A_W05
S2RAC_W06	is knowledgeable in the use of thermodynamic cycles in the design of cryogenic refrigerators and liquefiers, distinguishes between types and explains the construction of refrigerating and cryogenic liquefiers and has knowledge of the cryogenic separation of gas mixtures and describes the air separation plants, know the rules of safe handling of liquefied gases	T2A_W04 T2A_W05
S2RAC_W07	hasknowledge of properties of materials used in cryogenics and describes the effect of low temperatures on selected types of materials, lists and characterized cryogenic and has knowledge of construction materials, and thermal and electrical insulation used in cryogenic	T2A_W04 T2A_W05
S2RAC_W08	has knowledge of the principles of design, construction and	T2A_W04

	operation of freon and ammonia refrigeration systems and refrigeration systems, together with the relevant supporting installations	T2A_W05
S2RAC_W09	has knowledge of the thermodynamic basics of absorption refrigeration systems, distinguishes and describes the typical constructions of apparatus and other essential elements of the absorption refrigeration system	T2A_W04 T2A_W05
S2RAC_W10	has knowledge of the use of gas and cryogenic technology in the industry, energy, food processing, medicine and science	T2A_W04 T2A_W06 T2A_W07
S2RAC_W11	has knowledge of the theoretical foundations of superconductivity and the classification of superconductors; explains the use of superconductors in power generation, medical diagnostics and research equipment	T2A_W04 T2A_W05
S2RAC_W12	has knowledge of the system description cryogenic, distinguishes and characterizes the typical types of systems for cooling and low temperature thermal stabilization devices used in industry, medicine and research installations	T2A_W04
SKILLS		
S2INN_U01	Is able to prepare and present a presentation on selected topics of thermodynamics, which are applicable in refrigeration, cryogenics and low temperature physics; can lead a constructive discussion regarding the above presentation	T2A_U04
S2RAC_U02	can calculate the transition parameters and processes used in refrigeration compressor, refrigeration cycles can assign single and cascade; is able to estimate the power consumption and cooling equipment selected compressor cooling system	T2A_U09
S2RAC_U03	can measure performance and determine the thermal balances of vapor compression refrigeration systems, can analyze cooling cycle using phase diagrams; can analyze the dependence of the parameters of cycle on the construction and the operation of vapor compression refrigeration units	T2A_U08
S2RAC_U04	is able to design heat pump for specific requirements and applications; is able to perform necessary thermodynamic calculations for heat pumps and choose the appropriate equipment and fixtures	T2A_U15 T2A_U19
S2RAC_U05	can calculate the parameters of the processes used in cryogenics, can draw selected cryogenic processes and cycles using phase diagrams of various cryogenic agents; is able to use diagrams of cryogenic binary mixtures;	T2A_U09
S2RAC_U06	can handle liquefied gases while maintaining safety rules; is able to estimate and measure the heat transfer through the cryogenic insulation; can analyze parameters of the cryogenic refrigerators and liquefiers; can measure and analyze variability properties of materials at low temperatures, including superconductors	T2A_U08
S2RAC_U07	can design freon and ammonia refrigeration systems; is able to develop technological assumptions and guidelines and to choose location, concept of realization and the type of	T2A_U15 T2A_U17 T2A_U19

	installation; can develop schematics of refrigeration systems and select necessary elements	
S2RAC_U08	can use phase diagrams for absorption refrigeration; can calculate process parameters of the absorption refrigerating apparatus	T2A_U09
S2RAC_U09	is able to design absorption chilling units and carry out their thermal and hydraulic calculations as well as to identify characteristic points of the processes occurring in these devices	T2A_U15 T2A_U19
S2RAC_U10	is able to design equipment and components used in the gas and cryogenic installations according to selected design codes and taking into account existing norms; can choose the necessary auxiliary equipment and safety devices, and develop technical documentation; can make initial economic evaluation of cryogenic equipment	T2A_U14 T2A_U15 T2A_U17 T2A_U19
S2RAC_U11	is able to use advanced calculation software for thermal and hydraulic analysis of the devices used in low-temperature applications	T2A_U07

MATRIX OF CORRELATION BETWEEN EDUCATIONAL OUTCOMES/ EFFECTS IN THE FIELD OF TECHNICAL SCIENCES AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY

2nd level, main field of study *Mechanical Engineering and Machine Building* (MBM), general academic profile

Legend: IAP – Process Systems Engineering, ILO – Engineering of Aviation, INN – Low Temperature Engineering, RAC – Refrigeration and Cryogenics, MUE – Power Engineering Machines and Devices

Symbol of the educational outcome in the field of technical sciences	Description of the educational outcomes/ effects in the field of technical sciences	Reference to educational outcomes for 1st level, main field of study MBM					
		Main field of study effects	Specialization effects				
			IAP	ILO	INN	RAC	MUE
KNOWLEDGE							
T2A_W01	has expanded and broadened knowledge of mathematics, physics and chemistry and other areas related to the studied discipline necessary to formulate and solve complex tasks in the field of the studied discipline	K2MBM_W02 K2MBM_W03 K2MBM_W04	S2IAP_W01 S2IAP_W03 S2IAP_W04 S2IAP_W08	S2ILO_W03 S2ILO_W04 S2ILO_W05			
T2A_W02	has detailed knowledge in the field of study related to the studied discipline	K2MBM_W03	S2IAP_W02 S2IAP_W07				S2MUE_W05
T2A_W03	has organized, general knowledge and theoretical grounding including key issues related to the studied discipline	K2MBM_W01 K2MBM_W02 K2MBM_W04 K2MBM_W05 K2MBM_W06	S2IAP_W01 S2IAP_W02 S2IAP_W03 S2IAP_W04 S2IAP_W07	S2ILO_W02 S2ILO_W04 S2ILO_W06 S2ILO_W08 S2ILO_W09	S2INN_W01	S2RAC_W01	S2MUE_W03 S2MUE_W04 S2MUE_W10 S2MUE_W11 S2MUE_W13
T2A_W04	has detailed knowledge and theoretical grounding connected with the chosen issues in the field of the studied discipline	K2MBM_W03	S2IAP_W03 S2IAP_W05 S2IAP_W06 S2IAP_W08	S2ILO_W02 S2ILO_W03 S2ILO_W04 S2ILO_W05	S2INN_W02 S2INN_W03 S2INN_W04 S2INN_W05	S2RAC_W02 S2RAC_W03 S2RAC_W04 S2RAC_W05	S2MUE_W01 S2MUE_W02 S2MUE_W06 S2MUE_W07

			S2IAP_W09 S2IAP_W10	S2ILO_W07 S2ILO_W08 S2ILO_W09 S2ILO_W10	S2INN_W06 S2INN_W07 S2INN_W08 S2INN_W09 S2INN_W10	S2RAC_W06 S2RAC_W07 S2RAC_W08 S2RAC_W09 S2RAC_W10 S2RAC_W11 S2RAC_W12	S2MUE_W08 S2MUE_W09 S2MUE_W12
T2A_W05	has knowledge of trends in development and the most crucial and newest achievements in scientific disciplines and fields of study related to the studied discipline and other related scientific disciplines	K2MBM_W02			S2INN_W02 S2INN_W03 S2INN_W04 S2INN_W06 S2INN_W10	S2RAC_W02 S2RAC_W03 S2RAC_W04 S2RAC_W06 S2RAC_W07 S2RAC_W08 S2RAC_W09 S2RAC_W11	
T2A_W06	has fundamental knowledge of the lifecycle of devices, objects and technical systems	K2MBM_W05 K2MBM_W06		S2ILO_W07 S2ILO_W08 S2ILO_W10	S2INN_W03 S2INN_W07 S2INN_W08	S2RAC_W10	
T2A_W07	knows fundamental methods, techniques, tools and materials used for solving simple engineering tasks in the field of the studied discipline	K2MBM_W01	S2IAP_W01 S2IAP_W02 S2IAP_W05 S2IAP_W06 S2IAP_W07 S2IAP_W08 S2IAP_W09 S2IAP_W10	S2ILO_W01	S2INN_W07	S2RAC_W10	
T2A_W08	has fundamental knowledge necessary to understand social, economical ,legal and other non-technical factors of engineering activities as well as taking them into consideration in engineering practice	K2MBM_W07		S2ILO_W06			
T2A_W09	has fundamental knowledge of	K2MBM_W07					

	management, including quality management and running a business	K2MBM_W08					
T2A_W10	knows and understands basic concepts and rules related to industrial property protection and copyright laws and knows the necessity of these laws and rules in managing intellectual property resources; is able to use patent information resources						
T2A_W11	knows general rules related to establishing and developing individual entrepreneurial activity, using knowledge of scientific disciplines and fields of study related to the studied discipline	K2MBM_W08					
SKILLS							
1) general skills (not related to the area of engineering education)							
T2A_U01	is able to obtain information from literature, databases and other properly selected sources, either in English or another foreign language regarded as a language for international communication in the studied discipline ; is able to integrate obtained information, interpret and critically evaluate it, draw conclusions, formulate and justify opinions in full	K2MBM_U04	S2IAP_U05 S2IAP_U10 S2IAP_U11	S2ILO_U06 S2ILO_U10			
T2A_U02	is able to communicate in their professional environment and other environments using various techniques, either in English or another foreign language regarded as a language for international communication in the studied discipline	K2MBM_U08 K2MBM_U09					
T2A_U03	is able to prepare a scientific study in Polish language and also a short scientific	K2MBM_U07		S2ILO_U10			S2MUE_U08

	report, with the results of own research, in a foreign language regarded as a basic one in the scientific disciplines and fields of study related to the studied discipline						
T2A_U04	is able to prepare and give an oral presentation concerning detailed issues in the field of the studied discipline both in Polish and a foreign language	K2MBM_U06			S2INN_U01 S2INN_U09	S2RAC_U01	
T2A_U05	is able to establish directions of further education and follow the process of self-learning	K2MBM_U06 K2MBM_U07					
T2A_U06	has language skills in scientific disciplines and fields of study related to the studied discipline according to CEFR requirements for B2+ level	K2MBM_U08					
2) fundamental engineering skills							
T2A_U07	is able to use information and communication technologies necessary to perform tasks typical of engineering activities	K2MBM_U03 K2MBM_U05	S2IAP_U01 S2IAP_U08 S2IAP_U09 S2IAP_U13	S2ILO_U03 S2ILO_U09 S2ILO_U12	S2INN_U06 S2INN_U11	S2RAC_U01 S2RAC_U11	
T2A_U08	is able to plan and run experiments including measurements and computer simulations, interpret results and draw conclusions	K2MBM_U01 K2MBM_U02	S2IAP_U07 S2IAP_U08 S2IAP_U09 S2IAP_U12	S2ILO_U07	S2INN_U03 S2INN_U05	S2RAC_U03 S2RAC_U06	S2MUE_U01 S2MUE_U03 S2MUE_U04 S2MUE_U05
T2A_U09	is able to use analytical, simulation and experimental methods to formulate and solve engineering tasks as well as simple research problems	K2MBM_U03 K2MBM_U05	S2IAP_U01 S2IAP_U03 S2IAP_U07 S2IAP_U08 S2IAP_U09 S2IAP_U12	S2ILO_U01 S2ILO_U04 S2ILO_U05 S2ILO_U06 S2ILO_U07 S2ILO_U08 S2ILO_U11	S2INN_U02 S2INN_U04	S2RAC_U02 S2RAC_U05 S2RAC_U08	S2MUE_U07 S2MUE_U09 S2MUE_U10 S2MUE_U11
T2A_U10	is able - while formulating and solving engineering tasks- to integrate knowledge	K2MBM_U03 K2MBM_U04	S2IAP_U03 S2IAP_U04	S2ILO_U06			S2MUE_U02 S2MUE_U06

	of scientific disciplines and fields of studies appropriate for the specialization and apply the system approach which also takes into account non- technical aspects	K2MBM_U05	S2IAP_U11				S2MUE_U09 S2MUE_U10
T2A_U11	is able to formulate and test hypotheses connected with engineering problems and simple research problems	K2MBM_U03 K2MBM_U04					S2MUE_U02
T2A_U12	is able to assess the usefulness and possibilities of new achievements (technological and technical) in the field of the studied discipline	K2MBM_U01		S2ILO_U07			S2MUE_U04
T2A_U13	is prepared to work in an industry environment and knows safety rules in the workplace	K2MBM_U04					
T2A_U14	is able to carry out primary economic analysis of undertaken engineering activities		S2IAP_U03 S2IAP_U13	S2ILO_U02 S2ILO_U03	S2INN_U08	S2RAC_U10	S2MUE_U06
3) skills directly connected with solving engineering tasks							
T2A_U15	is able to carry out critical analysis of functioning and also assess – particularly in reference to the studied discipline- existing technical solutions, in particular devices, objects, systems, processes, and services	K2MBM_U04	S2IAP_U02 S2IAP_U05 S2IAP_U10 S2IAP_U11 S2IAP_U13	S2ILO_U02 S2ILO_U04	S2INN_U07 S2INN_U08 S2INN_U10	S2RAC_U04 S2RAC_U07 S2RAC_U09 S2RAC_U10	
T2A_U16	is able to plan improvements in existing technical solutions	K2MBM_U03	S2IAP_U02	S2ILO_U09			S2MUE_U06
T2A_U17	is able to identify and formulate specifications of complex engineering tasks specific for the studied discipline including untypical tasks considering their non-technical aspects	K2MBM_U05	S2IAP_U04		S2INN_U07 S2INN_U08	S2RAC_U07 S2RAC_U10	
T2A_U18	is able to assess the usefulness of	K2MBM_U02	S2IAP_U01				

	methods and tools for solving an engineering task specific for the studied discipline, and notice limitations of these methods and tools; is able – by applying conceptually new methods- to solve complex engineering tasks specific for the studied discipline, including untypical tasks and tasks with a research component		S2IAP_U12				
T2A_U19	is able – according to a given specification which considers non – technical aspects- to design a complex device, object, system or process specific for the studied discipline and complete this project – at least partially- using appropriate methods, techniques and tools, adapting already existing tools or by creating new tools	K2MBM_U05	S2IAP_U05 S2IAP_U10		S2INN_U08 S2INN_U10	S2RAC_U04 S2RAC_U07 S2RAC_U09 S2RAC_U10	S2MUE_U06 S2MUE_U10
SOCIAL COMPETENCES							
T2A_K01	understands the necessity of a lifetime learning process; is able to inspire and organize the process of learning for others	K2MBM_K01					
T2A_K02	realizes the significance and understands non-technical aspects and consequences of engineering activity and especially its influence on the natural environment and the related responsibility for decisions	K2MBM_K02					
T2A_K03	is able to cooperate and work in a group, taking up different roles	K2MBM_K03					
T2A_K04	is able to set clear priorities leading to the realization tasks set by himself or others	K2MBM_K04					
T2A_K05	identifies correctly and solves dilemmas connected with the profession	K2MBM_K01					
T2A_K06	is able to think and act in an	K2MBM_K05					

	entrepreneurial way						
T2A_K07	realizes the social role of technical university graduates and especially understands the need to formulate information and share it with society, e.g. through mass media, in relation to achievements in environmental engineering and other aspects of engineering activity; makes attempts at sharing such information and opinions in an understandable way	K2MBM_K02					