Attachement no. 1 to Programme of Education
(for studies beginning in the year 2015/2016)

LEARNING OUTCOMES FOR THE FIELD OF STUDY

(Assumed educational effects)

Faculty: Mechanical and Power Engineering
Field of study: MECHANICAL ENGINEERING AND MACHINE BUILDING (MBM)
Specialization: Low Temperature Engineering (INN)
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.

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 Specialization INN	**DESCRIPTION OF THE MAIN LEARNING OUTCOMES** **After completion of the post-graduate studies in the field of *Mechanical Engineering and Machine Building* in specialization *Low Temperature Engineering* 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 one and several variables	T2A_W01 T2A_W03 T2A_W07
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
S2INN_W01	has knowledge of 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	T2A_W01 T2A_W03

	thermodynamics of superconductivity, thermal stability and heat transfer at low temperatures	
S2INN_W02	is knowledgeable in the use of thermodynamic cycles in the design of cryogenic refrigerators and liquefiers, distinguishes between the types and explains the construction of refrigerating and cryogenic liquefiers; has knowledge of cryogenic separation of gas mixtures and describes the air separation plants, know the rules of safe handling of liquefied gases	T2A_W04 T2A_W05
S2INN_W03	has knowledge of thermodynamic cycles used in the compressor and absorption refrigeration systems, distinguishes and describes the construction of compressor and absorption-type refrigerators, characterizes and selects components refrigeration and air conditioning systems for industrial, commercial and domestic applications	T2A_W04 T2A_W05 T2A_W06
S2INN_W04	has knowledge of properties of materials and agents used in refrigeration and cryogenics; describes the effect of low temperatures on selected types of materials, lists and characterizes refrigerants, coolants and cryogenic liquids; has knowledge of construction materials as well as thermal and electrical insulation used in cryogenics	T2A_W04 T2A_W05
S2INN_W05	has knowledge of the applicable standards for low temperature equipment and installations; has the expertise in design codes for pressure equipment for storage and transportation of liquefied gases	T2A_W04
S2INN_W06	has knowledge of coupled energy systems (cogeneration, tri-generation, poly-generation), distinguishes and describes the technologies to convert various forms of energy - thermal, electrical and mechanical	T2A_W04 T2A_W05
S2INN_W07	has knowledge of the low temperature equipment and systems; distinguishes between the types and describes the internal structure of cryogenic equipment; understands the basic principles of design, manufacturing and testing of low-temperature equipment and installation	T2A_W04 T2A_W06 T2A_W07
S2INN_W08	has knowledge of the use of gas and cryogenic technology in the industry, energy, food processing, medicine and science	T2A_W04 T2A_W06
S2INN_W09	has knowledge of the description of cryogenic system, distinguishes and characterizes common types of systems for cooling and thermal stabilization of low temperature devices used in industry, medicine and research installations	T2A_W04
S2INN_W10	has knowledge of theoretical foundations of superconductivity as well as classification of superconductors; explains the use of superconductors in power generation, medical diagnostics and research equipment	T2A_W04 T2A_W05
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 fields of science and scientific disciplines relevant to the Power Engineering in accordance with the requirements for level B2+ and possibly for level C1+ of the European Framework of Reference for Languages	T2A_U06
K2MBM_U09	has language skills in the fields of science and scientific disciplines relevant to the *Power Engineering* in accordance with the requirements for level A1 or A2 or B1 of the European Framework of Reference for Languages	T2A_U02
S2INN_U01	is able to prepare and present a presentation on selected topics of thermodynamics applicable to low temperature engineering; can lead a constructive discussion regarding the above presentation	T2A_U04
S2INN_U02	can calculate parameters of the processes used in cryogenics; can sketch diagrams of processes and cycles on phase diagrams of cryogenic agents; can use the diagrams of cryogenic binary mixtures	T2A_U09
S2INN_U03	can handle the liquefied gases while maintaining safety; is able to estimate and measure the heat transfer through the cryogenic insulation; is can analyze the parameters of the cryogenic refrigerators and liquefiers; can measure and analyze the variability of materials properties at low temperatures, including superconductors	T2A_U08
S2INN_U04	can calculate transition parameters and processes used in the vapor compression refrigeration and absorption, know how to use phase diagrams used in vapor compression refrigeration and absorption.	T2A_U09
S2INN_U05	can measure performance and prepare thermal balance sheets for the refrigeration equipment; can reproduce analyzed cooling cycles on phase diagrams; analyze the dependence of the cycle parameters on construction of the refrigeration systems	T2A_U08
S2INN_U06	Is able to use the selected software to build three-dimensional computer models and drawings; iable to use advanced	T2A_U07

	calculation programs for the analysis of thermo-mechanical devices found in low-temperature	
S2INN_U07	can develop coupled energy systems in cogeneration and tri-generation with the use of various energy conversion technologies	T2A_U15 T2A_U17
S2INN_U08	is able to design low-temperature devices and system components according to the selected design codes and taking into account the existing norms; is able to design low temperature systems and devices and choose the necessary auxiliary and safety equipment; is able to develop procedures for cryogenic equipment and process testing and prepare installation of the cryogenic equipment; can make initial economic evaluation of cryogenic equipment	T2A_U14 T2A_U15 T2A_U17 T2A_U19
S2INN_U09	is able to prepare and give a presentation on the use of low-temperature technology in designated industries; can argue the advantages and disadvantages of these technologies	T2A_U04
S2INN_U10	is able to develop and analyze block diagrams and flow diagrams of cryogenic installations; can structure cryogenic systems and estimate the size and the basic parameters of functional components of the cryogenic system	T2A_U15 T2A_U19
S2INN_U11	is able to use advanced calculation programs for thermal and hydraulic analysis of low-temperature devices	T2A_U07
SOCIAL COMPETENCIES		
K2MBM_K01	understands the need to improve professional, personal and social skills; identifies and resolves dilemmas associated with his profession	T2A_K01 T2A_K05
K2MBM_K02	is aware of the importance of non-technical aspects and impacts of social engineering and the role of university graduates	T2A_K02 T2A_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
K2MBM_K06	is aware of the necessity of individual and group activities that go beyond the activities of engineering	T2A_K02 T2A_K03

MATRIX OF CORRELATION BETWEEN EDUCATIONAL OUTCOMES/ EFFECTS IN THE FIELD OF TECHNICAL SCIENCES AND EDUCATIONAL EFFECTS
for 2nd level, main field of study *MECHANICAL ENGINEERING AND MACHINE BUILDING*
in specialization *LOW TEMPERATURE ENGINEERING*
general academic profile

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 2nd level main field of study	
		main field of study *Mechanical Engineering and Machine Building*	specialization *Low Temperature Engineering*
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	
T2A_W02	has detailed knowledge in the field of study related to the studied discipline	K2MBM_W03	
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	S2INN_W01
T2A_W04	has detailed knowledge and theoretical grounding connected with the chosen issues in the field of the studied discipline	K2MBM_W03	S2INN_W02 S2INN_W03 S2INN_W04 S2INN_W05 S2INN_W06 S2INN_W07 S2INN_W08 S2INN_W09 S2INN_W10
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
T2A_W06	has fundamental knowledge of the lifecycle of devices, objects and technical systems	K2MBM_W05 K2MBM_W06	S2INN_W03 S2INN_W07 S2INN_W08
T2A_W07	knows fundamental methods, techniques, tools and materials used for solving simple engineering tasks in the field of the studied discipline	K2MBM_W01	S2INN_W07
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	
T2A_W09	has fundamental knowledge of management, including quality management and running a business	K2MBM_W07 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	
UMIEJĘTNOŚCI			
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	
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_U09	
T2A_U03	is able to prepare a scientific study in Polish language and also a short scientific 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	K2MBM_U07	
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
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	

T2A_U07	is able to use information and communication technologies necessary to perform tasks typical of engineering activities	K2MBM_U03 K2MBM_U05	S2INN_U06 S2INN_U11
T2A_U08	is able to plan and run experiments including measurements and computer simulations, interpret results and draw conclusions	K2MBM_U01 K2MBM_U02	S2INN_U03 S2INN_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	S2INN_U02 S2INN_U04
T2A_U10	is able to formulate and test hypotheses connected with engineering problems and simple research problems	K2MBM_U03 K2MBM_U04 K2MBM_U05	
T2A_U11	is able to formulate and test hypotheses connected with engineering problems and simple research problems	K2MBM_U03 K2MBM_U04	
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	
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		S2INN_U08
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	S2INN_U07 S2INN_U08 S2INN_U10
T2A_U16	is able to plan improvements in existing technical solutions	K2MBM_U03	
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	S2INN_U07 S2INN_U08
T2A_U18	is able to assess the usefulness of 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	K2MBM_U02	
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	S2INN_U08 S2INN_U10
SOCIAL COMPETENCES			
T2A_K01	understands the necessity of a lifetime learning process; is able to inspire and organize the process	K2MBM_K01	

	of learning for others		
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 K2MBM_K06	
T2A_K03	is able to cooperate and work in a group, taking up different roles	K2MBM_K03 K2MBM_K06	
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 entrepreneurial way	K2MBM_K05	
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	