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 • Power 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 machines," according to the requirements for level B2 of the European Framework of Languages	T2A_U02 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 • Power 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 1

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: PROCESS SYSTEMS ENGINEERING (IAP)

Learning outcome for post-graduate studies in specialization: IAP	DESCRIPTION OF THE MAIN LEARNING OUTCOMES After completion of the post-graduate studies in the field of Mechanics and Machine Design and specialization Process Systems Engineering, the graduate:	Reference to learning outcomes for the area of technical sciences (T)
	KNOWLEDGE	
S2IAP_W01	has extended, theoretically founded knowledge of the dynamics of unit operations in process engineering; understands their progression and knows defining relations; knows equipment and its applicability to implement dynamic unit operations in the industry	T2A_W01 T2A_W03 T2A_W07
S2IAP_W02	has knowledge on construction of process equipment components such as shells, bottoms, lids, legs, supports, flange connections, grills, rotating drums and high-pressure apparatus components; has knowledge on use of these elements in constructing the entire apparatus; knows methods of their calculation and the rules of selection; has expertise in the selection of parameters of the process equipment and necessary equipment to ensure trouble-free and safe operation	T2A_W02 T2A_W03 T2A_W07
S2IAP_W03	has structured knowledge of the preparation, implementation and documentation of engineering projects; knows specialized software for engineering design calculations and project management; knows limits and possibilities of adapting standard software design to support specific work environment	T2A_W01 T2A_W03 T2A_W04
S2IAP_W04	has basic knowledge on thermodynamic transformations and phase equilibriums	T2A_W01 T2A_W03
S2IAP_W05	has structured and theoretically founded knowledge in the field of heat transfer and methods of increasing the concentration of solutions by evaporation of the liquid; knows basic constructions of heat exchangers and evaporators; understands principles of heat and mass balances in evaporation	T2A_W04 T2A_W07
S2IAP_W06	has extended knowledge on static and kinetic aspects of crystallization; knows in detail the methods of industrial crystallization, apparatus to implement them as well as procedures for their proper selection to achieve high quality crystalline product while reducing energy consumption; has structured knowledge on mathematical modeling and design	T2A_W04 T2A_W07

	of crystallizers	
S2IAP_W07	has detailed knowledge of processes of thermal diffusion separation of substances; has in-depth knowledge on the design of apparatus for thermal diffusion separation of substances; knows methods of their design, mathematical modeling and operation; knows the applicability of thermal diffusion processes in selected industries and for environmental protection	T2A_W02 T2A_W03 T2A_W07
S2IAP_W08	has basic understanding on how to develop the concept of technological process as well as on its balancing; knows rules for drawing process diagrams; has structured knowledge on the selection of apparatus, control and measuring equipment for the implementation of technological process; knows the basis of economic assessment and has expertise in scaling up processes	T2A_W01 T2A_W04 T2A_W07
S2IAP_W09	has extended, theoretically founded knowledge of the physical, chemical, structural and mechanical properties of solutions, suspensions, granular and porous materials; has basic knowledge on rheology and multiphase flows; understands and can explain the methods of measurement using image analysis; knows in detail the methods for measuring selected properties of solutions, suspensions and particulate and porous materials	T2A_W04 T2A_W07
S2IAP_W10	has extended and in-depth knowledge of the industrial methods of separation of solid particles suspended in liquids and gases; knows allocation methods and knows how to select proper method for separation of individual suspensions; has expertise in combining and optimization of different separation methods; knows apparatus for separation; explains the operation of separation nodes	T2A_W04 T2A_W07
SKILLS		
S2IAP_U01	is able to analyze and measure basic parameters of unit operations in process engineering; knows how to calculate and select operating parameters for high performance equipment operatio; is able to analyze and compare the experimental results with calculated theoretical results	T2A_U07 T2A_U09 T2A_U18
S2IAP_U02	can perform calculations, manufacturing drawings and assembly drawing of the selected apparatus of the process, knows how to select components based on equipment standards and manufacturers' catalogs; is able to use the device to ensure safe operation of the apparatus and to develop a method of its exploitation	T2A_U15 T2A_U16
S2IAP_U03	is able to plan in detail the engineering project and outline its critical components; is able to define and assign resources necessary for effective its implementation; is able to use specialized software to carry out design calculations and presentations; can prepare initial economic evaluation	T2A_U09 T2A_U10 T2A_U14
S2IAP_U04	Is able to resolve issues and problems associated with phase transitions and interfacial equilibrium	T2A_U10 T2A_U17
S2IAP_U05	is able to do the project of the selected type mixer including detailed calculations of hydraulics and hydrodynamics, mixing, stirring power, thermal and endurance calculations;	T2A_U01 T2A_U15 T2A_U19

	knows how to perform assembly drawing and manufacturing drawings of the mixer and its components	
S2IAP_U06	is able to prepare and give a presentation on such topics as: construction and operation of mixing equipment, liquid velocity distributions in mixers, hydraulic mixing of heterogeneous systems, mixing of granular materials, mixing in flow apparatus, mixing power and the exchange of heat and mass transfer in mixing vessels	T1A_U01 T1A_U04
S2IAP_U07	is able to determine experimentally heat transfer coefficients is apparatus submitted to varying operating conditions; is able to present results in numerical and graphical form, and perform comparative analysis of experimentally and theoretically obtained coefficients	T2A_U08 T2A_U09
S2IAP_U08	knows how to perform mass, energy and population balance in the mold based on the experimental data; is able to determine kinetic parameters of the crystallization process in intermittent and continuously operating crystallizer; is able to select the operating parameters of the batch crystallizer in order to obtain high quality crystalline product	T2A_U07 T2A_U08 T2A_U09
S2IAP_U09	Is able to experimentally determine mass transfer coefficients and calculate the efficiency of mass transfer process and to determine the amount of filling for the rectification column; is able to analyze and compare the experimental results with theoretical calculations	T2A_U07 T2A_U08 T2A_U09
S2IAP_U10	is able to perform detailed calculations of selected thermal diffusion processes aimed at the selection and design of equipment; knows how to use mathematical models of these processes and their equilibrium data	T2A_U01 T2A_U15 T2A_U19
S2IAP_U11	can make installation project for the selected technological process with specified production capacity, including: the material and energy balance of the installation, selection of devices and equipment, detailed design calculations and assumptions for apparatus that require individual construction, technological schematics of apparatus, spatial planning of measurement equipment and apparatus	T2A_U01 T2A_U10 T2A_U15
S2IAP_U12	is able to experimentally determine concentration of solutions, choose proper method and analyze the particle size distribution; knows how to calculate the strength parameters of granular material and how to make measurements of the structural properties of sediments	T2A_U08 T2A_U09 T2A_U18
S2IAP_U13	is able to identify and describe a method for separating of suspensions required by the specific process conditions; is able to estimate process parameters and the efficiency of the methods of separation; is able to define basic dimensions of machinery and apparatus for separation of suspensions in given process conditions; can make a preliminary economic analysis of the separation process	T2A_U07 T2A_U15 T2A_U14

Appendix 2

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: ENGINEERING OF AVIATION (ILO)

Learning outcome for post-graduate studies in specialization: ILO	**DESCRIPTION OF THE MAIN LEARNING OUTCOMES** **After completion of the post-graduate studies in the field of Mechanics and Machine Design and specialization Engineering of Aviation, the graduate:**	**Reference to learning outcomes for the area of technical sciences (T)**
	KNOWLEDGE	
S2ILO_W01	has basic knowledge of preliminary gas-dynamic calculations of turbine engines and their main components; has knowledge on the strength calculations of the basic structural components of gas turbine engines	T2A_W07
S2ILO_W02	identifies the design features of aircrafts; explains the methodology for determining loads on components of aircrafts; describes the structure of components and systems of aircrafts	T2A_W03 T2A_W04
S2ILO_W03	defines types of vibrations and vibration characteristics of aircraft components; is able to identify methods of preventing vibrations in aircraft components	T2A_W01 T2A_W04
S2ILO_W04	characterizes advanced hydrodynamic phenomena occurring in flows; defines laws describing the flow around objects; explains methods for describing the turbulent flow; formulates the theory of boundary layer	T2A_W01 T2A_W03 T2A_W04
S2ILO_W05	describes how to derive the equations of motion for an aircraft; defines loads acting in flight; describes the aero-elasticity of the aircraft; identifies the impact of aero-elasticity effects on the dynamics of motion of the aircraft and the flight safety	T2A_W01 T2A_W04
S2ILO_W06	lists the main documents underlying the regulation of aviation; explains concepts in the field of aviation law	T2A_W03 T2A_W08
S2ILO_W07	has knowledge of the life and reliability of the aircraft; is able to identify the determinants of the level of reliability of the aircraft; is able to describe the principles of forecasting the reliability in the exploitation	T2A_W04 T2A_W06
S2ILO_W08	lists the purpose and tasks of the energy systems of the aircraft; describes their design, explains the methodology of calculation of the energy systems of the aircraft	T2A_W03 T2A_W04 T2A_W06
S2ILO_W09	explains the equations of motion of the helicopter; interprets helicopter flight from the equations of motion	T2A_W03 T2A_W04
S2ILO_W10	lists the main concepts of aviation safety; describes the methodology of accident investigation and explains ways to improve air safety	T2A_W04 T2A_W06

SKILLS		
S2ILO_U01	can perform the calculation of parameters of the stream in the flow channel in the turbine engine and its main units	T2A_U09
S2ILO_U02	is able to select parameters of the engine cycle; can design the flow channel geometry for the turbine engine and carry out preliminary strength calculations of basic gas turbine engine components	T2A_U14 T2A_U15
S2ILO_U03	performs strength calculations of the main components of an aircraft	T2A_U07 T2A_U14
S2ILO_U04	carries out the design process of the selected energy system of an aircraft	T2A_U09 T2A_U15
S2ILO_U05	is able to identify the type of vibration on aircraft components and calculate the natural frequency of the selected aircraft components	T2A_U09
S2ILO_U06	solves problems related to the similarity of flows, apply laws of fluid mechanics to determine parameters of flow	T2A_U01 T2A_U09 T2A_U10
S2ILO_U07	analyzes and interprets velocity, pressure and temperature fields derived from commercial CFD software (Computational Fluid Dynamics); uses information provided by these programs	T2A_U08 T2A_U09 T2A_U12
S2ILO_U08	calculates aerodynamic derivatives and analyzes vibration on aircraft components; can determine the critical speed of Flatter type vibration	T2A_U09
S2ILO_U09	uses advanced software engineering MES in designing aircraft structures	T2A_U07 T2A_U16
S2ILO_U10	search, interpret and properly apply the rules of the air	T2A_U01 T2A_U03
S2ILO_U11	calculates helicopter flight parameters on the basis of equations of motion	T2A_U09
S2ILO_U12	perform a preliminary design of the drive system for helicopter	T2A_U07

Appendix 3

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: LOW TEMPERATURE ENGINEERING (INN)

Learning outcome for post-graduate studies in specialization: INN	**DESCRIPTION OF THE MAIN LEARNING OUTCOMES** **After completion of the post-graduate studies in the field of Mechanics and Machine Design and specialization Low Temperature Engineering, the graduate:**	**Reference to learning outcomes for the area of technical sciences (T)**
	KNOWLEDGE	
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 thermodynamics of superconductivity, thermal stability and heat transfer at low temperatures	T2A_W01 T2A_W03
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	T2A_W04

	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_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		
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 calculation programs for the analysis of thermo-mechanical devices found in low-temperature	T2A_U07
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	T2A_U14 T2A_U15 T2A_U17 T2A_U19

	procedures for cryogenic equipment and process testing and prepare installation of the cryogenic equipment; can make initial economic evaluation of cryogenic equipment	
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

Appendix 5

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: POWER ENGINEERING MACHINES AND DEVICES (MUE)

Learning outcome for post-graduate studies in specialization: MUE	DESCRIPTION OF THE MAIN LEARNING OUTCOMES After completion of the post-graduate studies in the field of Mechanics and Machine Design and specialization Power Engineering Machines and Devices, the graduate:	Reference to learning outcomes for the area of technical sciences (T)
	KNOWLEDGE	
S2MUE_W01	explains the structure and function of the main components of the boiler and associated equipment; describes solutions used in the modern boiler technology; describes the principle of agent circulation in evaporators of steam boilers; formulates heat transfer equations for engineering calculations of heat exchangers in the boiler; identifies and characterizes the advantages and disadvantages of renewable and alternative fuels in power boilers	T2A_W04
S2MUE_W02	describes and explains the principles of construction, operation and maintenance of burners and furnaces (gas-fueled, liquid and solid); knows the rules of safe operation of burners and furnaces; describes and explains the technology of clean combustion; is able to identify specific ways to help reduce emissions during combustion of fuels	T2A_W04
S2MUE_W03	is familiar with the construction and operation of specialty pumps; is able to perform basic calculations of selected specialty pumps (e.g. frictional, circulatory, a water ring, centrifugal pumps with a small number of blades, with the free movement); knows specifics of pumps used in selected industries; is able to define requirements for seals and the drive	T2A_W03
S2MUE_W04	knows the general requirements and tests for piping and the role of pipelines in power plants; can list and describe heat losses and pressure drops during compressible flow in pipes; knows the basic types and grades of steel for pipelines; has basic knowledge of the stresses in the pipe wall due to temperature and yielded by external loads; is able to describe the principles of compensation of thermal expansion of pipeline and pipeline suspension; knows fittings and has knowledge of the principles of operation of pipelines, possible interferences and failures	T2A_W03
S2MUE_W05	describes the characteristics and use of reciprocating internal combustion engines and external combustion; is	T2A_W02

	familiar with the requirements and properties of motor fuels and knows the rules of the combustible mixture formation and combustion properties of the spark-ignition engines; has maximum working knowledge of any circuit of the internal combustion engine; describes the exchange of charge and timing in 4-stroke engines, as well as goals, solutions and trends in the regulation and control of these engines; explains the cooling of engines and knows computational and design problems related thereto; knows characteristics of internal combustion engines; describes the principles and limitations of boost engines and design solutions of engine components	
S2MUE_W06	is familiar with the basic theoretical principles and the basic structures of steam and gas turbines; knows basic theory of turbine stage, the elements and components of a steam and gas turbine and the principles of their operation	T2A_W04
S2MUE_W07	is familiar with the basic construction of turbines and hydrology; knows basis for the construction of reaction turbines; knows types and specificity of hydropower plants; can choose parameters basic types of hydroelectric plants	T2A_W04
S2MUE_W08	has knowledge of the transport pipeline of granular materials (ash, ore concentrates, etc.) and hydraulic transport machinery; describes the hydro-mixtures flow patterns in pipes; knows rheological properties of mixtures and their classification; explains the methods and algorithms for calculation of hydraulic transport systems; knows economic issues of hydro-transport; describes principles of operation and the importance of hydro-transport for the protection of environment	T2A_W04
S2MUE_W09	describes the operation of hydraulic machines and the specificity of their research; knows measuring methods (simple and high-tech)	T2A_W04
S2MUE_W10	describes the principle of operation and construction of a power blocks; knows the rules governing the legal and technical exploitation of machinery and power equipment	T2A_W03
S2MUE_W11	knows the purpose and design features of special-purpose turbines e.g. for district heating, with unregulated and regulated vents, for marine, for transportation, etc.; characterizes gas turbines - of airplanes, air, turbo systems, etc. and describes the trends of contemporary design steam and gas turbines	T2A_W03
S2MUE_W12	has knowledge of the and low-power energy power stations and boilers used in the energy industry and the municipal sector; knows trends associated with the implementation of a new generation of biofuel-fired boilers, waste, explains the use of related and associated hybrid systems; knows conditions for the design, collection and operation of boilers and low-power stations	T2A_W04
S2MUE_W13	has structured knowledge of mechanical and pneumatic transport, in particular systems used in power generation	T2A_W03
SKILLS		
S2MUE_U01	can independently conduct research used on the example of	T2A_U08

	a comprehensive energy measurements of various types of pumps	
S2MUE_U02	analyzes successive stages of starting the power unit from cold state and hot state; analyzes successive stages of withdrawal to the reserve power unit (hot or cold state) or for the maintenance	T2A_U10 T2A_U11
S2MUE_U03	developing flow characteristics of a steam turbine and two adjustable vents; conducts heat and mass flow calculations for microturbines and radial turbines	T2A_U08
S2MUE_U04	carries out calculations for stoichiometric combustion, thermal of the boiler, flow and the flow resistance; selects burners; selects the boiler and boiler equipment; prepare the heat balance of the boiler	T2A_U08 T2A_U12
S2MUE_U05	selects designs and performs basic calculations movement of selected types of conveyors	T2A_U08
S2MUE_U06	calculates the heat transfer performance of the boiler when changing fuel; analyzes the impact of co-firing heat transfer in the boiler; evaluate the economic aspect of the use of renewable and alternative fuels to produce heat and electricity	T2A_U10 T2A_U14 T2A_U16 T2A_U19
S2MUE_U07	perform basic design calculations of gas and dust burner and low-emission hearth	T2A_U09
S2MUE_U08	presents selected issues related to heat engines	T2A_U03
S2MUE_U09	calculates flow parameters at the Bendemann nozzle and at the de Laval nozzle; runs flow calculations with specified degree of reactivity; calculates energy losses	T2A_U09 T2A_U10
S2MUE_U10	adjusts parameters of the installed run-of-the-river power plants; selects water turbines for a particular installation conditions; calculates the desired Kaplan type rotor turbine; calculates reaction turbine wheel	T2A_U09 T2A_U10 T2A_U19
S2MUE_U11	performs sieve analysis of the bulk material; prepares the thermal performance of a centrifugal pump for hydraulic transport; prepares the thermal performance of a positive displacement pump for hydraulic transport	T2A_U09

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	K2MBM_W03	S2IAP_W03 S2IAP_W05 S2IAP_W06	S2ILO_W02 S2ILO_W03 S2ILO_W04	S2INN_W02 S2INN_W03 S2INN_W04	S2RAC_W02 S2RAC_W03 S2RAC_W04	S2MUE_W01 S2MUE_W02 S2MUE_W06

	the studied discipline		S2IAP_W08 S2IAP_W09 S2IAP_W10	S2ILO_W05 S2ILO_W07 S2ILO_W08 S2ILO_W09 S2ILO_W10	S2INN_W05 S2INN_W06 S2INN_W07 S2INN_W08 S2INN_W09 S2INN_W10	S2RAC_W05 S2RAC_W06 S2RAC_W07 S2RAC_W08 S2RAC_W09 S2RAC_W10 S2RAC_W11 S2RAC_W12	S2MUE_W07 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	K2MBM_W07		S2ILO_W06			

	consideration in engineering practice						
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					
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	K2MBM_U08 K2MBM_U09					

	techniques, either in English or another foreign language regarded as a language for international communication in the studied discipline						
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		S2ILO_U10			S2MUE_U08
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	K2MBM_U01 K2MBM_U02	S2IAP_U07 S2IAP_U08 S2IAP_U09	S2ILO_U07	S2INN_U03 S2INN_U05	S2RAC_U03 S2RAC_U06	S2MUE_U01 S2MUE_U03 S2MUE_U04

	results and draw conclusions		S2IAP_U12				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 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_U03 K2MBM_U04 K2MBM_U05	S2IAP_U03 S2IAP_U04 S2IAP_U11	S2ILO_U06			S2MUE_U02 S2MUE_U06 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 –	K2MBM_U04	S2IAP_U02 S2IAP_U05	S2ILO_U02 S2ILO_U04	S2INN_U07 S2INN_U08	S2RAC_U04 S2RAC_U07	

	particularly in reference to the studied discipline- existing technical solutions, in particular devices, objects, systems, processes, and services		S2IAP_U10 S2IAP_U11 S2IAP_U13		S2INN_U10	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 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	S2IAP_U01 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 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					