PROGRAMME OF EDUCATION

FACULTY: **FACULTY OF MECHANICAL AND POWER ENGINEERING**

MAIN FIELD OF STUDY: . **Mechanical Engineering and Machine Building**

in area of technical science

EDUCATION LEVEL: 2nd level, magister inżynier

FORM OF STUDIES: full-time

PROFILE: general academic

SPECIALIZATION: REFRIGERATION AND CRYOGENICS

LANGUAGE OF STUDY: English

Content:

Faculty Council Resolution of 26.09.2012
In effect since 01.10.2012

Edited adjustment_April 2014

Attachment no 2 to Programme of Education

PROGRAMME OF STUDIES

1. Description

Number of semesters:3	*Number ECTS points necessary to obtain qualifications:90*
Prerequisites (particularly for second-level studies): Admission requirements (particularly in the case of the second cycle) degree qualifications and competence to continue education in college secondary education: knowledge of mathematics, physics and chemistry, enabling understanding of the fundamentals of mechanics, materials and principles of construction machinery, mechanical knowledge, strength of materials and construction of foundations, enabling the understanding and design of the basic machine components, the ability to use to formulate and solve engineering tasks analytical methods, simulation and experimental knowledge of fluid flow including all thermal processes, knowledge of the record structure using 2D CAD 3D and ability to communicate in English, and the presentation and documentation of the experiment, and the presentation and documentation of a project tasks.	*Upon completion of studies graduate obtains* *professional degree of: magister* *2nd level qualifications*
Possibility of continuing studies:	*Graduate profile, employability:* Graduate, employment opportunities: Graduates have the knowledge and skills in the following areas: engineering, design, manufacture and operation of machines and manufacturing systems and environmental technologies and safety. It is ready to use creative methods and technologies supporting the design, manufacture and operation of the equipment and the choice of materials engineering, management and development of production in industrial and

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	process control, research in research institutes, management design companies in the field of construction machinery and technological processes of doing business. It has the necessary knowledge and skills in the design, testing and operation of machines and devices that generate low temperatures, corresponding to -35 ° C in cooling and in the range of 120 K (-153 ° C) fractions of Kelvin in cryogenics, including for the technology, science and medicine. He knows a foreign language at level B2 + and a second foreign language at A1 or A2 level.
Indicate connection with University's mission and its development strategy:	The programme of education is consistent with the mission of the University in the transfer of knowledge and skills to maintain high quality of education and the development of creative, critical and tolerant personality of students by developing and nurturing a strong sense of academic community based on communication and social rights of students and employees.

2. Fields of science and scientific disciplines to which educational effects apply: technical science

3. Concise analysis of consistency between assumed educational effects and labour market needs : The expected increase in education provide engineering competencies gained on the first level of education, especially in terms of knowledge and skills, with particular emphasis on creativity in solving specific technical problems. The training program equips graduates with the attributes thus enabling him to adapt to the rapidly changing requirements of the labor market.

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4. List of education modules

4.1. List of obligatory modules

4.1.1 List of general education modules

4.1.1.1 *Obligatory main-field-of-study* modules

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Field-of-study educational effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1	MSN0463	Mechanics analytical	2					K2MBM_W03	30	60	2	1,00	T	Z			K	Ob
2	MSN1362	Modern Engineering Materials	1					K2MBM_W02	15	30	1	0,50	T	Z			K	Ob
3	MSN1362	Modern Engineering Materials			1			K2MBM_U02	15	30	1	0,75	T	Z		P	K	Ob
4	MSN1362	Modern Engineering Materials					1	K2MBM_U06	15	30	1	0,75	T	Z		P	K	Ob
5	MSN0531	Mechatronics and Control Systems	2					K2MBM_W01	30	90	3	1,50	T	E			K	Ob
6	MSN0531	Mechatronics and Control Systems			2			K2MBM_U01 K2MBM_K02 K2MBM_K03 K2MBM_K04	30	60	2	1,50	T	Z		P	K	Ob
7	MSN0614	Modelling and Optimisation	1					K2MBM_W04	15	60	2	1,00	T	E			K	Ob
8	MSN0614	Modelling and Optimisation			2			K2MBM_U03	30	90	3	2,25	T	Z		P	K	Ob
9	MSN1493	Integrated Production Systems	2					K2MBM_W06	30	60	2	1,00	T	Z			K	Ob
10	MSN1493	Integrated Production Systems			1			K2MBM_U05	15	30	1	0,75	T	Z		P	K	Ob
11	MSN0034	Failure Analysis of Machines and Devices	2					K2MBM_W05 K2MBM_K05	30	60	2	1,00	T	Z			K	Ob
12	MSN0034	Failure Analysis of Machines and Devices			1			K2MBM_U04	15	30	1	0,75	T	Z		P	K	Ob
13	MSN1561	Master Seminar					2	K2MBM_U06 K2MBM_U07 K2MBM_K01 K2MBM_K03 K2MBM_K04 K2MBM_K05	30	60	2	1,50	T	Z		P	K	Ob
		Total	10		7		3		300	690	23	14,25						

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Altogether for general education modules

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
10		7		3	300	690	23	14,25

4.2 List of optional modules

4.2.1.1 Liberal-managerial subjects modules *(min. 2 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Field-of-study educational effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1	HSN100200BK	Humanities Course	1					K2MBM_W07 K2MBM_K02	15	30	1	0,50	T	Z	O		KO	W
2	ZSN100200BK	Management Course	1					K2MBM_W08	15	30	1	0,50	T	Z	O		KO	W
		Total	2						30	60	2	1,00						

4.2.1.2 *Foreign languages* module *(min.3 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Field-of-study educational effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1	JZL100655BK	Foreign Language (continuation), level B2+		1				K2MBM_U08	15	30	1	0,75	T	Z	O	P	KO	W
2	JZL100655BK	oreign Language (second), any level		3				K2MBM_U09	45	60	2	1,50	T	Z	O	P	KO	W
		Total		4					60	90	3	2,25	3					

Altogether for optional modules

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
2	4				90	150	5	3,25

4.2.2 List of basic sciences modules

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[7] Optional – enter W, obligatory – enter Ob

4.2.2.1 *Master Individual Student Projekt* module *(min.9 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Field-of-study educational effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1	MSN1533	Master Individual Student Project				6		K2MBM_U07 K2MBM_K01 K2MBM_K04 K2MBM_K05	90	270	9	4,00	T	Z		P	K	W
		Total				6			90	270	9	4,00						

4.2.2.2 *Master Thesis* module *(min. 20 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Field-of-study educational effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1	MSN1611	Master Thesis						K2MBM_U07 K2MBM_K01 K2MBM_K04 K2MBM_K05		600	20	4,00	T	Z		P	K	W
		Total								600	20	4,00						

Altogether for basic sciences modules:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
			6		90	870	29	8,00

4.2.3 List of main-field-of-study modules

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[2]Traditional – enter T, remote – enter Z
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[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
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[7] Optional – enter W, obligatory – enter Ob

4.2.3.1 *Refrigeration and Cryogenics* **module** *(min 33 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Field-of-study educational effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1	MSN1225	Thermodynamic Fundamentals of Refrigeration, Cryogenics and Low Temperature Physics	2					S2RAC_W01	30	60	2	1,00	T	Z			S	W
2	MSN1225	Thermodynamic Fundamentals of Refrigeration, Cryogenics and Low Temperature Physics					1	S2RAC_U01	15	30	1	0,75	T	Z		P	S	W
3	MSN0161	Compressor Refrigeration Systems	2					S2RAC_W02	30	60	2	1,00	T	E			S	W
4	MSN0161	Compressor Refrigeration Systems		2				S2RAC_U02	30	60	2	1,50	T	Z		P	S	W
5	MSN0161	Compressor Refrigeration Systems			2			S2RAC_U03	30	60	2	1,50	T	Z		P	S	W
6	MSN0183	Refrigerants and Coolants	1					S2RAC_W03	15	30	1	0,50	T	Z			S	W
7	MSN0831	Heat Pumps	1					S2RAC_W04	15	30	1	0,50	T	Z			S	W
8	MSN0831	Heat Pumps				1		S2RAC_U04	15	30	1	0,75	T	Z		P	S	W
9	MSN1051	Air-condition Systems	1					S2RAC_W05	15	30	1	0,50	T	Z			S	W
10	MSN0341	Cryogenics	2					S2RAC_W06	30	60	2	1,00	T	E			S	W
11	MSN0341	Cryogenics		1				S2RAC_U05	15	30	1	0,75	T	Z		P	S	W
12	MSN0341	Cryogenics			2			S2RAC_U06	30	60	2	1,50	T	Z		P	S	W
13	MSN0342	Cryogenic Materials and Fluids	1					S2RAC_W07	15	30	1	0,50	T	Z			S	W
14	MSN1041	Cooling Systems and Refrigeration Plants	1					S2RAC_W08	15	30	1	0,50	T	Z			S	W
15	MSN1041	Cooling Systems and Refrigeration Plants				2		S2RAC_U07	30	60	2	1,50	T	Z		P	S	W
16	MSN0121	Absorption Refrigeration	2					S2RAC_W09	30	60	2	1,00	T	E			S	W
17	MSN0121	Absorption Refrigeration		1				S2RAC_U08	15	30	1	0,75	T	Z		P	S	W
18	MSN0121	Absorption Refrigeration				1		S2RAC_U09	15	30	1	0,75	T	Z		P	S	W
19	MSN1151	Gas and Cryogenic Technologies	2					S2RAC_W10	30	60	2	1,00	T	Z			S	W
20	MSN1151	Gas and Cryogenic Technologies				2		S2RAC_U10	30	60	2	1,50	T	Z		P	S	W
21	MSN0035	Applied Superconductivity	1					S2RAC_W11	15	30	1	0,50	T	Z			S	W
22	MSN0343	Cryogenic Systems	1					S2RAC_W12	15	30	1	0,50	T	Z			S	W
23	MSN0245	Introduction to Numerical Flow Phenomena Analysis			1			S2RAC_U11	15	30	1	0,75	T	Z		P	S	W
		Total	17	4	5	6	1		495	990	33	20,50						

Altogether for main-field-of-study modules:

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Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
17	4	5	6	1	495	990	33	20,50

4.4 Diploma dissertation module

Type of diploma dissertation	**magister**	
Number of diploma dissertation semesters	**Number of ECTS points**	**Code**
1	20	**MSN1611**
Character of diploma dissertation		
Experiment/Literature survey/ Project, computer program, etc.		
Number of BK[1] ECTS points	4	

5. Ways of verifying assumed educational effects

Type of classes	**Ways of verifying assumed educational effects**
lecture	e.g. examination, progress/final test
class	e.g. progress/final test
laboratory	e.g. pretest, report from laboratory
project	e.g. project defence
seminar	e.g. participation in discussion, topic presentation, essay
training	e.g. report from training
diploma dissertation	prepared diploma dissertation

6. Total number of ECTS points, which student has to obtain from classes requiring direct academic teacher-student contact (enter total of ECTS points for courses/groups of courses denoted with code BK[1])

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46 ECTS

7. Total number of ECTS points, which student has to obtain from basic sciences classes

Number of ECTS points for obligatory subjects	0
Number of ECTS points for optional subjects	0
Total number of ECTS points	0

8. Total number of ECTS points, which student has to obtain from practical classes, including laboratory classes (enter total number of ECTS points for courses/group of courses denoted with code P)

Number of ECTS points for obligatory subjects including laboratory and projects	8	11
Number of ECTS points for optional subjects including laboratory and projects *including master thesis*	20 *20*	48
Total number of ECTS points		59

9. Minimum number of ECTS points, which student has to obtain doing education modules offered as part of university-wide classes or other main field of study (enter number of ECTS points for courses/groups of courses denoted with code OG)

5 ECTS points

10. Total number of ECTS points, which student may obtain doing optional modules (min. 30% of total number of ECTS points)

46ECTS points

11. Range of diploma dissertation

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1. Theoretical issues

1.1. Unattainability of absolute zero and its consequences.
1.2. Relation between temperature and energy.
1.3. Entropy minimization method of the optimization of thermal processes and equipment.
1.4. Linde's refrigeration cycle and. The basic parameters and their representation on lgp-h diagram. The comparison with the Carnot cycle.
1.5. The differences between the theoretical and real compressor refrigeration cycle. Interpretation on lgp-h diagram.
1.6. The energetic outcome of an industrial absorption refrigeration chiller working with NH3-H2O mixture and it's interpretation in the h-ξ diagram.
1.7. The energetic outcome of an industrial absorption refrigeration chiller working with LiBr-H2O mixture. The designing process.
1.8. Compression, work, heat, optimization of the process, significance for refrigeration and cryogenic cycles.
1.9. Trigeneration and its applicability.
1.10. Isentropic expansion, throttling, free exhaustion, description and comparison of the processes.
1.11. Joule-Thomson liquefaction and refrigeration cycle, depiction on T-s diagram, energy balance, liquefaction and refrigeration capacity.
1.12. Claude liquefaction and refrigeration cycle, depiction on T-s diagram, energy balance, liquefaction and refrigeration capacity.
1.13. Cryocoolers – principles of operation, flow diagrams.
1.14. Methods of obtaining the temperatures below 1 K.
1.15. Thermodynamic principles of gas separation.
1.16. Superconductivity – definition and physical explanation.
1.17. Construction of the Linde's compressor refrigeration cycle- determination of the basic temperatures which describe the cycle.
1.18. Isentropic efficiency of the refrigeration compressors.
1.19. Sources of irreversibility of the Linde's compressor refrigeration cycle.
1.20. COP factor and the volume capacity for the compressor heat pump cycle and refrigeration cycle.

2. Construction issues

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2.1. Basic rules of suction, liquid and discharge pipelines construction in compressor refrigeration plants.
2.2. The possibilities of increasing of the COP of the compressor refrigeration cycles.
2.3. The construction types of the heat exchangers used in refrigeration and their mathematical models. The possibilities of increasing of the COP in
2.4. the LiBr- H20 refrigeration chillers.
2.5. Heat pumps. The possibilities of exploitation of the atmospheric air, water and ground as a source of heat.
2.6. Heat exchangers used in cryogenic equipment.
2.7. Insulation in refrigeration and cryogenic devices, superinsulation.
2.8. Air rectification installation – flow scheme.
2.9. Materials used in cryogenic equipment.
2.10. Transfer lines for liquid gases – design principles.
2.11. Storage tanks for liquid gases – design principles.
2.12. Types of refrigeration compressors and their basic parameters. Possibilities of motor overload protection.
2.13. Construction of magnetic coolers.
2.14. Possibilities of condensation pressure regulation.
2.15. Two stage refrigeration cycle and its graphical interpretation on the lgp-h diagram.
2.16. The refrigeration cycle with the economizer its graphical interpretation on the lgp-h diagram.

3. Eksploitation issues

3.1. Natural and synthetic refrigerants and the basic rules of their application to the refrigeration plants.
3.2. Self regulation of the compressor refrigeration plants. The most often problems and their representation in the lgp-h diagram.
3.3. The application of the rack compressor systems. Basic rules of construction and possibilities of capacity regulation.
3.4. Possibilities of application of absorption machines in cogeneration and trigeneration systems.
3.5. Systems for heat recovery from compressor refrigeration plants.
3.6. Safety in handling of liquid gases.
3.7. Cryostating of superconducting magnets.
3.8. Lubrication of low temperature components in cryogenic devices.
3.9. Energy consumption and thermodynamic efficiency of cryogenic devices.
3.10. Technology of superfluid helium – application examples.

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3.11. Safety regulations referred to the refrigeration plants.
3.12. Evaporation pressure regulation.
3.13. Hot gas defrosting of unit coolers in the refrigeration plants.
3.14. “Free- cooling” systems in refrigeration plants.

12. Requirements concerning deadlines for crediting courses/groups of courses for all courses in particular modules

No.	*Course code*	*Name of course*	*Crediting by deadline of... (number of semester)*
	Uchwała RW nr 4/D/2008 z dnia 19.09.2008	The condition for admission the student to the execution of the master thesis module is to pass all subjects in plan of studies in the semester prior to the semester of graduation	

13. Plan of studies (attachment no 2)

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[7] Optional – enter W, obligatory – enter Ob