Riga Technical University
Project: Erasmus+: Development of practically-oriented student-centred education in the field of modelling of Cyber-Physical Systems" CybPhys"
Project number: 609557-EPP-1-2019-1-LV-EPPKA2-CBHE-JP – ERASMUS+ CBHE
Authors: Anastasia Zhiravetska, Anatolijs Zabasta
Version: 1.1

Co-funded by the Erasmus+ Programme of the European Union

Ex Ante Evaluation Report

Deliverable Nr 1

CybPhys Consoliated Report

Anatolijs Zabasta
Dr.sc.ing.
Senior researcher
Riga Technical University
Faculty of Power and Electrical Engineering
Institute of Industrial Electronics and Electrical Engineering

Anastasia Zhiravetska
Dr.sc.ing.,
Prof., senior researcher
Riga Technical University
Faculty of Power and Electrical Engineering
Institute of Industrial Electronics and Electrical Engineering

Co-funded by the Erasmus+ Programme of the European Union

Record of changes

Version#	Status of document	Date	Author	Comments
0.1	Draft	09.03.2020	A.Žiravecka	1st draft
0.2	Draft	29.03.2020	J.Peutemon	2nd draft
0.3	Draft	14.04.2020	A.Zabašta	3rd draft
1.0	Draft	26.04.2020.	A.Žiravecka	4th draft
1.1	Document	19.04.2020	A.Zabašta	Final version

Co-funded by the Erasmus+ Programme of the European Union

CONTENT

Co-funded by the Erasmus+ Programme of the European Union

Co-funded by the Erasmus+ Programme of the European Union

1. SUMMARY OF THE PROJECT

The Ex-Ante report is a description of existing study programms and current situation at partner universities and the motivation for curicula development and modernisation. Higher education institutions from Latvia, Cyprus, Belgium, Belarus and Ukraine contributed to elaboration of this Report. The Report reflects the existing situation related education programs and courses in partner's universities of Belarus and Ukraine and also depicts the plans of development the new curricula and modernization of the existing one at BSU, GSU, MSPU, CNTU, KNU, KHNAHU universities.

In tjios Report, several Belarusian partners at SWOT analysis pointed out such weaknesses as:

- Not enough financial resources for new and well-equipped classrooms and laboratories - GSU, MSPU;

- The lack of a clear understanding of the place of graduates with a bachelor degree and their professional duties in industrial and technological sectors, reduces the interest of industrial enterprises to such graduates – BSU.

The Ukrainian partners at SWOT analysis mentioned as weakness points the current method of financing, which negatively affects the long-term development planning and achievement of the main goals. One of the most serious shortcomings is too few strategic partnerships with international scientific institutions is manifested by the several partners. Additionally, the inability to fully comply with foreign counterparts of educational programs and curricula, teaching methods, simplification of mobility mechanisms and recognition of qualifications as well as the lack of practice in teaching disciplines in English does not allow to expand opportunities for intensifying the recruitment of foreign students and academic mobility.

Co-funded by the Erasmus+ Programme of the European Union

2. Belarusian State University (BSU)

2.1 Summary

The ex-ante report is a description of existing study programms and current situation at partner universities and motivation for project development.

The project involves higher education institutions from Latvia, Cyprus, Belgium, Belarus, Ukraine. Development of the curricular reform in Engineering and engineering trades is highlighted as a priority in all partner countries.

2.2. *Information about the national education system in the Republic of Belarus in 2018-2019.*

Currently, the higher education system of Belarus is at an intermediate stage of transition to the Bologna system. It temporarily combines two training systems: (4 + 1.8) and (5 + 1). For example, one of the participants in this project - the Faculty of Physics of BSU - works according to the mixed system, while the second participant in the project - the Faculty of Mechanics and Mathematics - completely switched to the Bologna system. The use of a mixed system of higher education in BSU and in Belarus as a whole is due to a number of circumstances. One of them is due to the continued demand for specialists (researchers and engineers) in the Belarusian labor market with 5 years of education without a master's degree (in universities, enterprises, factories, research institutes, design centers, etc.). The second reason is due to the fact that the Council of Republic of Belarusian Parlaiment has not yet adopted the new version of the Code of Education. The third circumstance is dictated by the specificity of the labor market in Belarus, where, due to the structure of the economy as a whole, in particular, the uneven degree of development of its various sectors, graduates with a bachelor's degree (after 4 years of study) are much less in demand than graduates with a specialist diploma (after 5 years of study).

In Ex-Ante report of BSU of 2015, when implementing of prevous project 561525-EPP-1-2015-1-LV-EPPKA2-CBHE-JP "Improvement of master-level education in the field of physical sciences in Belarusian universities" (Physics) ERASMUS+ program (2014-2017), we described the main goals and deliverables of academic studies for Specialists, their social

Co-funded by the Erasmus+ Programme of the European Union

and professional competences, the tasks of their professional activity, requirements for the level of training of graduates.

Below we give a brief description of the state of the education system in Belarus as a whole and, in particular, for Stages I and II of higher education at the Faculty of Mechanics and Mathematics and Faculty of Physics in BSU.

According to the acting Code of Education (adopted in December 2, 2010 by the House of Representatives and approved in December 22, 2010 by the Council of Republic of Belarusian Parlaiment), currently in the Republic of Belarus exists:

- basic education,
- additional education,
- special education (education and training of persons with special needs).

Basic education in Republic of Belarus includes the following levels:

- pre-school education;
- secondary education;
- vocational training;
- secondary special education;
- higher education;
- post-graduate education.

According to the acting Code of Education *Higher education* is the basic level education aimed at developing the personality of student, cadet or listener, their intellectual and creative abilities, receiving of a special theoretical and practical training by them, culminating in qualification "Specialist" with higher education or a master's degree.

Higher education is divided into two stages.

The I stage of higher education provides training of specialists who possess fundamental and special knowledge, skills and abilities with awarding them qualification "Specialist" for 5-year graduates and "Specialist" with bachelor level for 4-year graduates.

Higher education of stage I gives the right to continue their education at the II stage of higher education and employment in the received specialty (the direction of specialty, specialization) and qualification.

Co-funded by the Erasmus+ Programme of the European Union

The II stage of higher education (Masterships) provides in-depth training of specialist, forming of knowledge, practices and skills in teaching and research work with the assignment of a master's degree.

The II stage of higher education is directed on realization of educational programs for stage II higher education, forming the knowledge, practices and skills in teaching and research work to obtain a master's degree, and education program of for stage II higher education with in-depth training of specialist to obtain a master's degree.

The II stage of higher education gives graduates the right to continue their education at post-graduate education (post-graduate studentship or PhD level, see below) and employment in the specialty (the direction of specialty, specialization) and appropriate qualifications.

The term of the Stage II of higher education for full-time education is one year to one years 8 months (1.8).

The term of the Stage I higher education for the mostly complicated professions, defined by the Government of the Republic of Belarus, may be increased but not more than on one year.

Graduates of Stage II of higher education (masters) are eligible to continue their education at post-graduate (PhD) level.

Below we present a brief description and analysis of curricula introduced to education process in Faculty of Physics and Faculty of Mathematics and Mechanics since 2019-2020 education years. A list of descripted curricula is presented in Table.

Table 6

№	Curricula (Code of specialty, direction)	Date of entry into force
1	1-31 80 03 - Mathematics and Computer Science	01.09.2019
2	1-31 80 02 - Mechanics and Numerical Simulation	01.09.2019
3	1-31 80 20 - Applied Physics	01.09.2018
4	1-31 04 08 – Computer Physics	01.09.2018

Co-funded by the Erasmus+ Programme of the European Union

2.3. *Features of specialty 1-31 80 03 "Mathematics and Computer Science" on Faculty of Mechanics and Mathematics*

Program 1-31 80 03 "Mathematics and Computer Science" is academic education program for postgraduate students (masters level). The program is based on Higher Education Standard OCBO 1-31 80 03-2019. This program is research oriented and started in September 2019, substituting practical oriented masters programs.

SWOT analysis of the curricula

S - the strong sides of the curricula realization

1. The curricula at the Stage II begins after 4-year bachelor training programme fulfilling that allows one to concentrate on further specialization and research work during the master degree preparation.

2. The warranty of succession and continuity in the mastering of disciplines on Stage II of the double-stage the system "Bachelor (4 years) - Master (1.8 years)": from fundamental training in mathematics (at the beginning of the Stage I of training) - to highly specialized disciplines (in the the Stage II). The following main components of fundamental education in the field of mathematics and computer science can be singled out:

- mathematical training;
- training in the disciplines of general mathematics;
- training in the disciplines of special mathematics;
- training in the field of information and computer technologies;
- training on special subjects (both in the areas of specialties (e.g, teaching, engineering and managerial activities, and so on) and within the framework of specialization (e.g, Intelligent data analysis, etc.), the study of which provides the formation of skills for application of fundamental mathematical knowledge in practice.

As a consequence:

- The high level of fundamental training in mathematics of the Stage II graduates;
- The high level of mastering of special disciplines by graduates of the Stage II like "Intelligent data analysis" for the specialty 1-31 80 03 "Mathematics and Computer Science".
- The high scientific level of master's theses, achieved through good training (at the initial

Co-funded by the Erasmus+ Programme of the European Union

level of bachelor), significant time devoted to research work, and continuity in the conduction of research work by master students from course works and diploma theses (at the Stage I) - to the master's thesis (in the Stage II).

- In general, the training at the Stage II is aimed on preparation of master-level graduates, which can work in research institutions and universities with the possibility of post-graduate studies.

W - the weak sides of the curricula realization

- The difficulties in adapting the curricula for foreign students who do not possess the enough high level in Russian language that demands to organize teaching/learning process in English.

- Shortening the lecture courses and lab practices for bachelor-level students due to introducing of study practices and the need for preparation of bachelor's diplomas (at conservation of 2 course works, as previously) in the Stage I and the need for further harmonization of curricula for the Stage II of higher education for foreign students.

- Shortening the real training periods for bachelor-level students and for master-level students since 2 to one year 8 months gives additional risks for the lowering of education quality and demands re-arrangement of lecture courses, laboratory and study practices for their better harmonization with master-level curricula.

- Even for the Stage II of higher education with in-depth training, it is traced in BSU the preferred orientation of training on the research area, probably with some damage to the interests of the industry (while for the current transition system of high education in Belarus, needs of the industrial enterprises completely met by graduates with a diploma of 5-year specialist). So, the preferable orientation of educational programs on the sphere of science does not allow to establish sufficiently strong ties with industry.

O - opportunities outside the university

- Joining to the European Higher Education Area and the Eurasian Economic Union countries, with which the Republic of Belarus have close economic ties and in fact the single job market

- In general, the training by system "Specialist-bachelor (4 years) - Master (1.8 year)" enhancs the possibilities for the export of educational services to the countries outside the Eurasian Economic Union.

Co-funded by the Erasmus+ Programme of the European Union

T - threats of the successful realization of the curricula

- Small experience of Belarusian universities in realization of training by system "Specialist-Bachelor (4 years) - Master (1.8 year)" limits the possibilities for the export of educational services to the countries outside the Eurasian Economic Union.

- Existing administrative restrictions on the admission on the Stage II of higher education (merely about 7 % per cent of the graduates of the Stage I) does not stimulate the progress of the education on the Stage II.

- A small number of undergraduate graduates who can continue their education in the magistracy due to administrative restrictions leads to:
  - the low demand for master graduates in industry,
  - the desire of some bachelor graduates to continue their education outside Belarus.

- The lack of a clear understanding of the place of graduates with a master's degree and their professional duties in industrial and technological sector reduces the interest of industrial enterprises to such graduates. Having contacts between master students and the industry might be useful. E.g. by having internships in the industry, by doing a master thesis in collaboration with the industry, master students will become familiar with the industry and the industry will become familiar with the master students.

2.1. Type of curricula

Program 1-31 80 03 "Mathematics and Computer Science" is academic education program for postgraduate students (masters level). The program is based on Higher Education Standard OCBO 1-31 80 03-2019. This program is research oriented and started in 01.09.2019, substituting practical oriented masters programs.

2.2. Aims and objectives

The main aim of the program is to prepare masters with competencies in the following fields:

- scientific-pedagogical and educational-methodical;
- research;
- scientific and industrial;
- innovative;

Co-funded by the Erasmus+ Programme of the European Union

- organizational and managerial.

Magister should be able to solve the following tasks of professional activity:

- preparation and conduct of classes with students, the management of their research work, the development of educational and methodological support for the educational process;
- use of the achievements of science and advanced technologies in the field of natural sciences;
- planning and conducting research in the field of mathematics and information technology;
- development of practical recommendations on the use of mathematics and information technology in industry and education, the study of patentability and technical level of software development of information systems, the development of scientific and technical documentation;
- the use of modern methods of designing information systems, the use of web services, the design of technical documentation;
- analysis of the economic activity of enterprises operating in the field of high technology;
- development of plans and programs for organizing innovative activities, a feasibility study of innovative projects in professional activities;
- implementation of organizational and managerial functions.

2.3. Summary

Specialty 1-31 80 03 "Mathematics and Computer Science" in accordance with OCRB 011-2009 relates to the profile of education G "Natural Sciences", the direction of education 31 "Natural Sciences" and provides a master's degree.

2.4. Learning outcomes

A master-graduate after finishing this education program must have universal, in-depth professional and specialized competencies.

The master must have the following universal competencies:

- Be able to apply methods of scientific knowledge (analysis, comparison, systematization, abstraction, modeling, data validation, decision making, etc.) in independent research activities, generate and implement innovative ideas.

Co-funded by the Erasmus+ Programme of the European Union

- Be able to create and research new mathematical models in the natural sciences and information technology, to improve and develop concepts, theories and methods.
- To be able to apply the mathematical apparatus and methods of scientific knowledge to the study of mathematical structures and properties of mathematical objects.
- To be able to find, formulate and solve relevant and significant problems of theoretical and applied mathematics.

The master should have the following in-depth professional competencies:

- To be able to analyze the basic laws of random processes, develop probabilistic-statistical models for theoretical and applied problems.
- Own the basic methods of mathematical formalization of conflict situations in the economic and social spheres and the principles of their resolution.
- Be able to effectively use mathematical models in the design and development of innovative software.
- To be able to use the capabilities of modern software applications and mathematical packages to implement mathematical modeling technology in solving various applied problems.

2.5. Duration of the program

Duration of the program is 1 year 8 month for full-time learning and 2 years for distance learning.

2.6. Study courses and ECTS distribution

Course	Semester	Title of course	Type of work	Quantity of academic hours	Credits
1	1	Mathematical and Applied Statistics	lectures/lab.works	72	6
1	2	Decision theory	lectures/lab.works	72	6
1	3	Mathematical models in information technology	lectures/lab.works	36	3
1	3	Computer modelling applications	lectures/lab.works	36	3
1	1	Mathematical research methodology	lectures/seminars	36	3
1,2	1,2,3	Research seminar	seminars	396	12
1	1,2	Professional English	practical lessons	106	9

Co-funded by the Erasmus+ Programme of the European Union

1	2	AWS and cloud technology	lectures/lab.works	54	3
2	3	Android application development	lectures/lab.works	72	6
2	3	Interaction with embedded devices	lectures/lab.works	36	3
1	1	Machine learning	lectures/lab.works	52	3
1	2	Computer graphics in mobile applications	lectures/lab.works	36	3
2	3	Intelligent data analysis	lectures/lab.works	72	6
1	1	Native Android programming	lectures/lab.works	36	3
1	1	Functional programming and Scala technology	lectures/lab.works	36	3
1	2	Mobile app design templates	lectures/lab.works	36	3
1	2	Java EE technology	lectures/lab.works	36	3
1	1	Numerical information security algorithms	lectures/lab.works	54	3
2	3	Cryptotechnologies	lectures/lab.works	70	6
1	1	Analysis and design of business processes	lectures/lab.works	36	3
1	2	Internet marketing	lectures/lab.works	52	3
2	3	Optimization and SEO	lectures/lab.works	36	3
2	3	Augmented Reality	lectures/lab.works	70	6

3.7. Final assessment

Final assessment is held in the form of defense of a master's thesis.

In master's thesis, the postgraduate student have to demonstrate in-depth professional and specialized competencies, the ability to solve professional tasks at the modern level, the ability to integrate scientific knowledge, and scientifically argue his point of view. Upon completion of mastering the content of the master's educational program, a master's thesis should be aimed at solving a theoretical, experimental or applied problem in the field of mathematics, information technology, mathematical and computer modeling, including those related to the design of modern software applications in the field of information technology. The master's thesis should contain an abstract part and a research part, reflecting the in-depth professional and specialized competencies of a graduate in accordance with the specialty of training. The research part should be at least 50% of the dissertation.

3.8. Analysis of the programe for the relevance to the EQF level descriptors

Co-funded by the Erasmus+ Programme of the European Union

The program is relevant to the Level 7 (Master-level stage) of the EQF level descriptors.

During Erasmus project we will do:

1. Instead of course "Interaction with embedded devices" new course "Internet of Things" will be introduced.
2. Learning materials for courses "Computer modelling applications", "Internet of Things" will be developed.

2.4. Features of specialty 1-31 80 02 "Mechanics and Numerical Simulation" on Faculty of Mechanics and Mathematics

Program 1-31 80 02 "Mechanics and Numerical Simulation" is academic education program for students of bachelor level. The program is based on Higher Education Standard OCBO 1-31 80 02-2019. This program is research oriented and started in 01.09.2019, substituting specialists` programs with 4-year term of education.

4.1. SWOT analysis of the curricula

S - the strong sides of the curricula realization

1. The curricula for 4-year bachelor training programme of the Stage I begins education after entering of abiturients to BSU, so that its fulfilling allows one to concentrate on further specialization and proceeding education on Stage II for the master degree preparation.

2. The warranty of succession in the mastering of disciplines on Stage I which give fundamental knowledge in mathematics and mechanics. The following main components of fundamental education in the field of mathematics and computer science can be singled out:

- mathematical training;
- training in the disciplines of general mathematics;
- training in the disciplines of physica and mathematics for applications in the field of mechanics;
- training in the field of computer science and simulating technologies;
- training on special subjects (both in the areas of specialtiy (e.g, teaching, engineering and so on) and within the framework of specializations, the study of which

Co-funded by the Erasmus+ Programme of the European Union

provides the formation of skills for application of acquired mathematical and computer knowledge in practice.

As a consequence:

- The enough high level of fundamental training in mathematics and simulating techniques to prolong education on the Stage II to get master level;

- The high level of mastering of special disciplines by graduates of the Stage I like "Mathematical models in the mechanics of a deformable solids and the foundations of fracture mechanics" and "Numerical methods of continuum mechanics" for the specialty 1-31 80 02 "Mechanics and Numerical Simulation".

- In general, the training at the Stage I is aimed on preparation of bachelor-level specialists which can work in industrial companies using software with the possibility of master-level studies in future.

W - the weak sides of the curricula realization

.

- Shortening the lecture courses and lab practices for bachelor-level students due to introducing of study practices and the need for preparation of bachelor's diplomas (at conservation of 2 course works, as previously) gives additional risks for the lowering of education quality and demands re-arrangement of lecture courses, laboratory and study practices for their better harmonization between Stages I and II.

- The difficulties in adapting the curricula for foreign students who do not possess the enough high level in Russian language that demands to organize teaching/learning process in English.

O - opportunities outside the university

- Joining to the European Higher Education Area and the Eurasian Economic Union countries, with which the Republic of Belarus have close economic ties and in fact the single job market that enhancs the possibilities for the export of educational services, attracting students from abroad to Belarus.

Co-funded by the Erasmus+ Programme of the European Union

T - threats of the successful realization of the curricula

- Small experience of Belarusian universities in realization of trainings by Bachelor-level programs that lowers the possibilities for the export of educational services outside Belarus.

- Existing administrative restrictions on the admission on the Stage II of higher education (merely about 7 % per cent of the graduates of the Stage I) does not stimulate the progress of the education on the Stage I and entering graduate to masterships.

- The lack of a clear understanding of the place of graduates with a bachelor degree and their professional duties in industrial and technological sectors, reduces the interest of industrial enterprises to such graduates.

2.5. Type of curricula 1-31 03 02 "Mechanics and Mathematical Modeling"

The academic educational program 1-31 03 02 "Mechanics and Mathematical Modeling" corresponds to the educational standard of higher education for the training of specialists (with bachelor's level) and was introduced from 2013-09-01.

4.2. Aims and objectives

The main aim of the program is to prepare students with competencies in the following fields:

- research;
- scientific and industrial;
- organizational and management;
- innovative.

The Specialist-Bachelor should be prepared to solve the following tasks of professional activity:

- carrying out theoretical and applied research in the field of mechanics, applied mathematics and computer information technologies with subsequent processing of analytical, numerical and experimental data;

- development of practical recommendations on the use of the achievements of fundamental mechanics and applied mathematics, information technology in industry and education;

- modeling and application of information technologies to the implementation of the problems posed by fundamental mechanics, mechanics of a deformable solids, hydroaeromechanics, mechanics of natural processes, biomechanics, applied mechanics,

Co-funded by the Erasmus+ Programme of the European Union

dynamics and strength of machines, instruments and equipment, mechanics of robots and manipulators, nanomechanics;

- training and staff development;
- the implementation of organizational and managerial functions;
- the development of plans and programs for the organization of innovative activities, the feasibility study of innovative projects in professional activities.

4.3. Summary

Specialty 1-31 80 20 "Applid Physics" in accordance with OCRB 011-2009 relates to the profile of education G "Natural Sciences", the direction of education 31 "Natural Sciences" and provides a specialist degree of Bachelor level.

4.4. Learning outcomes

Mastering educational programs in the specialty 1-31 03 02 "Mechanics and numerical modeling" should ensure the formation of the following groups of competencies:

- academic competencies, including knowledge and skills in the studied disciplines, abilities and skills to learn;
- social and personal competencies, including cultural and value orientations, knowledge of the ideological, moral values of society and the state and the ability to follow them;
- professional competencies, including the ability to solve problems, develop plans and ensure their implementation in the chosen field of professional activity.

According to the results of the educational program fulfilling, the specialist must possess the following academic competencies:

- be able to apply basic scientific and theoretical knowledge to solve theoretical and practical problems.
- Own systemic and comparative analysis.
- Own research skills.
- Be able to work independently.
- Be able to generate new ideas (creativity).
- Have an interdisciplinary approach to solving problems.
- Have skills related to the use of technical devices, information management and working with a computer.

Co-funded by the Erasmus+ Programme of the European Union

- Have linguistic skills (oral and written communication).
- be able to learn, improve their skills throughout life.

After completing this educational program, a specialist must possess the following social and personal competencies:

- Be able to social interaction and interpersonal communications.
- Possess the skills of a healthy lifestyle.
- Be able to criticize and self-criticize (critical thinking).
- Be able to work in a team.

The specialist of Bachelor level must master the following professional competencies

- Develop practical recommendations on the use of scientific research, plan and conduct experimental research, investigate patentability and indicators of the technical level of software development of information systems, develop scientific and technical documents;
- Apply modern methods of designing information systems, use Web services, draw up technical documentation.
- Develop and test information systems, protect applications and data.

4.5. Duration of the program

Education in the specialty provides for the following forms:

- full-time (daytime, evening);
- correspondence (including remote).

Terms of obtaining a higher education of I level:

- The term for full-time higher education in the specialty 1-31 03 02 Mechanics and mathematical modeling is 4 years.
- The term for higher education in evening form is 5 years.
- The term for obtaining a higher education in correspondence form is 5 years.
- The term for obtaining higher education in distance form is 5 years.

4.6. Study courses and ECTS deistribution

Course	Semester	Title of course	Type of work	Quantity of academic hours	Credits
		The cycle of general			

Co-funded by the Erasmus+ Programme of the European Union

		scientific and professional disciplines			
		State component			
1	1	Belarusian language (professional vocabulary)	lectures/lab.works	72	3
1	2	Physics	lectures/lab.works	72	3
1	3	Programming Methods and Computer Science	lectures/lab.works	36	2
1	3	Human life safety	lectures/lab.works	36	2
1	1	Foreign language	lectures/seminars	36	2
		HEI component			
		Special Disciplines			
		State comonent			
1,2	1,2,3	Theoretical mechanics	seminars	396	12
1	1,2	Mathematical analysis	practical lessons	106	6
1	2	Algebra	lectures/lab.works	54	3
2	3	Analytic geometry	lectures/lab.works	72	3
2	3	Differential equations	lectures/lab.works	36	2
1	1	Equations of mathematical physics	lectures/lab.works	52	3
1	2	Continuum mechanics	lectures/lab.works	36	2
2	3	Resistance of materials and foundations of building mechanics	lectures/lab.works	72	3
1	1	Mathematical models of the mechanics of a deformable solids and the foundations of fracture mechanics	lectures/lab.works	36	2
1	1	Numerical methods of continuum mechanics	lectures/lab.works	36	2
		HEI component			
		Specialization Discipline			
1	2	Course work	lectures/lab.works	36	2
1	2	Optional disciplines	lectures/lab.works	36	2
1	1	Computing (training) practice, 4 weeks	lectures/lab.works	54	3
2	3	Research (industrial) practice, 4 weeks	lectures/lab.works	70	3
1	1	Graduate (industrial) practice, 8 weeks	lectures/lab.works	36	2
1	2	Diploma work	lectures/lab.works	52	3
2	3	Additional types of training	lectures/lab.works	36	-

4.7. Final assessment

Final certification is carried out by the state examination commission.

Co-funded by the Erasmus+ Programme of the European Union

Students who have fully completed the curriculum and training programs are allowed to final certification.

The final certification of students in the development of educational programs in the specialty 1-31 03 02 "Mechanics and mathematical modeling" is carried out in the form of a state exams in the specialty, specialization and defense of the thesis.

In preparation for the final certification, the competencies described in educational standard are formed or developed.

Requirements for the structure, content, volume and order of defense of the thesis are determined by the institution of higher education on the basis of educational standard and the Rules for the certification of students in the development of the content of educational programs of higher education.

Diploma works of a research, experimental, program-research character suggest the formation of theoretical and experimental research skills among students, including the ability to independently critical processing of scientific materials and sources and their practical implementation; ability to analyze modern experience; the ability to formulate conclusions, suggestions, recommendations, make assessments of research results, conduct engineering calculations, etc. They are aimed at deepening students' knowledge on actual problems; stimulating them to an independent scientific search. Diploma work (diploma project) is the qualification work of the student who is mastering the contents of the educational program of higher education at the first level, according to the level of implementation and the results of the defense of which the state examination commission concludes that it is possible for the student to be appropriately qualified.

4.8. Analysis of the programe for the relevance to the EQF level descriptors

The program is relevant to the Level 6 (ступень бакалавра) of the EQF level descriptors.

During Erasmus project we will do:

Preparation of new didactic materials for lecture courses

Co-funded by the Erasmus+ Programme of the European Union

2.6. Features of specialty 1-31 80 20 "Applied Physics" on Faculty of Physics

Program 1-31 80 20 "Applied Physics" is academic education program for students of bachelor level. The program is based on Higher Education Standard OCBO 1-31 80 02-2019. This program is research oriented and started in 01.09.2019, substituting specialists` programs with 5-year term of education.

4.9. SWOT analysis of the institution

S - the strong sides of the curricula realization

1. The curricula at the Stage II begins after fulfilling of 4-year training programme for specialists with bachelor level that allows one to concentrate on further specialization and research work during the master degree preparation.

2. The warranty of succession and continuity in the mastering of disciplines on Stage II of the double-stage the system "Bachelor (4 years) - Master (1.8 years)": from fundamental training in general and theoretical physics and mathematics (at the beginning of the Stage I of training) - to highly specialized disciplines (in the the Stage II) in the fields of in-depth applied physics and mathematics and computer simulation methods. The following main components of fundamental education in the field of applied physica, mathematics and computer science can be singled out:

- Technical Applications of Theoretical Physics
- Special practical trainings in computer simulation methods;
- Training in the disciplines of computer modelling of physical processes;
- Training in the disciplines of special mathematics for numerical physical experiments;
- Training in the field of information and computer technologies;
- Training on special subjects (both in the areas of specialties (e.g, teaching, engineering and managerial activities, and so on) and within the framework of specialization (e.g, Technical Applications of Theoretical Physics, Methods of mathematical modeling of physical processes, Computational methods in physics and physical experiment etc.), the study of which provides the formation of skills for application of improved theoretical physics and fundamental computer simulation knowledge in practice.

As a consequence:

Co-funded by the Erasmus+ Programme of the European Union

- The high level of fundamental training in applied physiscs, mathematics and simulation of physical processes of the Stage II graduates;

- The high level of mastering of special disciplines by graduates of the Stage II ilike "Physical applications of functional analysis and group theory", "Methods of mathematical modeling of physical processes" for the specialty 1-31 80 03 "Applied physics".

- The high scientific level of master's theses, achieved through good training at the initial level of bachelor, significant time devoted to research work, and continuity in the conduction of research work by master students from two course works and diploma work (at the Stage I) - to the master's thesis (in the Stage II).

- In general, the training at the Stage II is aimed on preparation of master-level specialists which can work in research institutions and universities with the possibility of post-graduate studies.

W - the weak sides of the curricula realization

- The difficulties in adapting the curricula for foreign students who do not possess the enough high level in Russian language that demands to organize teaching/learning process in English for them.

- Shortening the lecture courses and lab practices for bachelor-level students due to introducing of study practices and the need for preparation of bachelor's diplomas (at conservation of 2 course works, as previously) in the Stage I and the need for further harmonization of curricula for the Stage II of higher education for foreign students.

- Shortening the real training periods for bachelor-level students and for master-level students since 2 to 1 year and 8 months gives additional risks for the lowering of education quality and demands re-arrangement of lecture courses, laboratory and study practices for their better harmonization with master-level curricula.

- Even for the Stage II of higher education with in-depth training, it is traced in BSU the preferred orientation of training on the research area, probably with some damage to the interests of the industry (while for the current transition system of high education in Belarus, needs of the industrial enterprises completely met by graduates with a diploma of 5 year specialist). So, the preferable orientation of educational programs on the sphere of science does not allow to establish sufficiently strong ties with industry.

Co-funded by the Erasmus+ Programme of the European Union

O - opportunities outside the university

- Joining to the European Higher Education Area and the Eurasian Economic Union countries, with which the Republic of Belarus have close economic ties and in fact the single job market

- In general, the training by system "Specialist-bachelor (4 years) - Master (1.8 year)" enhancs the possibilities for the export of educational services to the countries outside the Eurasian Economic Union.

T - threats of the successful realization of the curricula

- Small experience of Belarusian universities in realization of training by system "Specialist-Bachelor (4 years) - Master (1.8 year)" limits the possibilities for the export of educational services to the countries outside the Eurasian Economic Union.

- Existing administrative restrictions on the admission on the Stage II of higher education (merely about 7 % per cent of the graduates of the Stage I) does not stimulate the progress of the education on the Stage II.

- A small number of undergraduate graduates who can continue their education in the magistracy due to administrative restrictions leads to:
  - the low demand for master graduates in industry,
  - the desire of some bachelor graduates to continue their education outside Belarus.

- The lack of a clear understanding of the place of graduates with a master's degree and their professional duties in industrial and technological sector reduces the interest of industrial enterprises to such graduates.

4.10. Type of curricula

Program 1-31 80 20 "Applied Physics" is academic education program for postgraduate students (masters level). The program is based on Higher Education Standard OCBO 1-31 80 20-2019. This program is research oriented and started in September 2019, substituting practical oriented masters programs.

Co-funded by the Erasmus+ Programme of the European Union

4.11. Aims and objectives

The main aim of the program is to prepare graduates with master level who have competencies in the following fields:

- scientific-pedagogical and educational-methodical;
- research;
- scientific and industrial;
- innovative;
- organizational and managarial;
- analitical.

The master should be prepared to solve the following tasks of professional activity:

- preparation and conduct of classes in physical and mathematical disciplines with students in gymnasiums and lyceums, institutions of secondary special and higher education, management of students' research work, development of educational and methodological support for the educational process;
- planning and conducting experimental and theoretical research in the field of applied physics and technology,
- development of practical recommendations on the use of the achievements of physics and advanced technologies in industry and education, the study of patentability and indicators of the technical level of development, the development of scientific and technical documentation;
- the use of modern design methods, the use of automation of a physical experiment, the production of materials and devices;
- development of plans and programs for organizing innovative activities, a feasibility study of innovative projects in professional activities;
- planning and organization of scientific-production and development work;
- analysis of the activities of enterprises operating in the field of high technology.Summary

4.12. Summary

Specialty 1-31 80 20 "Applid Physics" in accordance with OCRB 011-2009 relates to the profile of education G "Natural Sciences", the direction of education 31 "Natural Sciences" and provides a master's degree.

Co-funded by the Erasmus+ Programme of the European Union

5.5. Learning outcomes

A master after finishing this education program must have universal, in-depth professional and specialized competencies.

The master must have the following universal competencies:

- Be able to apply methods of scientific knowledge (analysis, comparison, systematization, abstraction, modeling, data validation, decision making, etc.) in independent research activities, generate and implement innovative ideas;
- be able to solve practical problems using the knowledge of theoretical physics, conduct professional scientific and technical activities, creatively comprehend scientific, technical and design information, analyze the process of solving scientific and technical problems;
- be able to use fundamental mathematical knowledge to analyze, verify, evaluate the completeness of information in the course of professional activity, if necessary, make up and synthesize missing information, work in conditions of uncertainty.

The master should have the following in-depth professional competencies:

- be able to use methods of theoretical physics to describe condensed matter, apply the acquired knowledge in independent developments, transfer skills to new areas of modern technology.
- be able to analyze and use in the course of professional activity modern methods of thermodynamics and statistical physics, carry out analytical and numerical calculations, use the results of calculations to create new objects of equipment and technologies.
- be able to use the methods of the theory of oscillations and waves to describe real systems and energy processes in them.
- be able to use the achievements of modern physics in solving applied problems, own a theoretical apparatus for analyzing the behavior of nonlinear dynamical systems.
- be able to build and develop mathematical models of physical phenomena, implement them using modern information technologies, analyze your product in the context of the latest achievements of mathematical modeling.
- be able to understand and apply the methods of a computational experiment in professional activities, to carry out qualified numerical calculations of physical objects and processes.

Co-funded by the Erasmus+ Programme of the European Union

5.6. Duration of the program

Duration of the program is 1 year 8 month for full-time learning and 2 years for distance learning.

5.7. Curricula with Study courses and ECTS distribution

Course	Semester	Title of course	Type of work	Quantity of academic hours	Credits
		State Component			
		Module "Technical Applications of Theoretical Physics"			
1	1	Solid State Physics	lectures	216	6
1	1	Applied problems in thermo-dynamics and statistical physics	Lectures/ pract. training	216	6
1	1	Physics of energy and wave processes	Lectures/ seminars	108	3
1	2	Modern problems of physics	Lectures/ seminars	108	3
		Module "Mathematical Methods in Physics"			
	1	Methods of mathematical modeling of physical processes	Lectures/ lab.works/ pract. training	324	9
	1	Computational methods in physics and physical experiment	lab.works	108	3
		Module "Research work on the subject of the dissertation"			
1,2	1,2,3,4	Research workshop	seminars	360	12
1	2	Course work on the subject of the master thesis		120	3
		Higher education component			
		Module "Applications of functional analysis and group theory in physics"			
1	1	Physical applications of functional analysis and group theory	Lectures/ pract. training	216	6
		Module "Technical Physics"			
1	2	The technique of modern experiment	Lectures/ pract. training	120	3

Co-funded by the Erasmus+ Programme of the European Union

1	2	Physics and chemistry of the surface	Lectures/ pract. training	120	3
1	2	Nuclear technology in materials science	Lectures/ pract. training	120	3
1	3	Laser processing of materials	Lectures/ seminars	90	3
1	3	Management of research and scientific and technical projects	Lectures/ seminars	90	3
		Module "Physics of low-dimensional systems"			
1	2	Physics of Low Dimension Systems / Energy Conversion Methods	Lectures/ seminars	120	3
1	2	Special laboratory practice "Modern diagnostics of materials and nanostructures" / Special laboratory practice "Methods of energy conversion"	lab.works	120	3
		Module "Nanomaterials in technology"			
2	3	Physics of Nanomaterials / Physical Material Science	Lectures/ seminars	198	6
2	3	Functional Electronics / Photovoltaics	Lectures/ seminars	198	6
		Module "Software and hardware for experiment automation"			
2	3	Intelligent microcontroller systems	Lectures/ seminars	198	6
2	3	Special laboratory practice "Microcontroller systems"	lab.works	90	3
		Module "Technology of nanomaterials"			
2	4	Technologies of nanocomposite and functional materials / Gas and hydrodynamics	lectures	90	3
2	4	Chemistry of Solids / Electrochemistry	Lectures/ seminars	198	6
2	4	Special laboratory practice "Research Lab. practice on the Physics of Nanomaterials" / Special laboratory practice "Experimental Research and Computer Modeling of the Physical Kinetics Processes"	lab.works	198	6
		Optional disciplines			
1	2	Fundamentals of Entrepreneurship	lectures	90	-
2	3	Creative Education Technologies in	Lectures/	108	3

Co-funded by the Erasmus+ Programme of the European Union

		Higher Education / Pedagogy and Psychology of Higher Education	pract. training		
		Additional types of training			
1-2	1-2	Philosophy and methodology of science	Lectures/ seminars	240	6
1-2	1-2	Foreign language	pract. training	220	6
1-2	1-2	Fundamentals of Information Technologies	Lectures/ pract. training	108	3
2	4	Training practice		2 weeks	6
2	4	Master thesis		2 weeks	6

5.8. Final assessment

Final assessment is held in the form of defense of a master's thesis.

In preparing the master's thesis, the undergraduate must demonstrate, based on the acquired knowledge and the formed universal, in-depth professional and specialized competencies, the ability to solve professional tasks at the modern level, the ability to integrate scientific knowledge, and scientifically argue his point of view.

Upon completion of mastering the content of the educational program of the master's program, a master's thesis should be aimed at solving a theoretical, experimental or applied problem in the field of physical and mathematical sciences.

The master's thesis should contain an abstract part and a research part reflecting the in-depth professional and specialized competencies of a graduate in accordance with the specialty of training. The research part should be at least 50% of the dissertation.

5.9. Analysis of the programe for the relevance to the EQF level descriptors

The program is relevant to the Level 7 of the EQF level descriptors.

During Erasmus project we will do:

Laboratory practice and Teaching/Learning materials for course "Methods of mathematical modeling of physical processes" will be modernized

Practical tasks for course "Methods of mathematical modeling of physical processes" will be developed/modernized

Study programs, practical tasks and Teaching/Learning materials for course "Physical applications of functional analysis and group theory" will be developed/modernized.

Co-funded by the Erasmus+ Programme of the European Union

Laboratory practices "Computational methods in physics and physical experiment" will be modernized

Special laboratory practice "Experimental Research and Computer Modeling of the Physical Kinetics Processes" will be modernized.

2.7. Features of specialty 1-31 04 08 "Computer Physics" on Faculty of Physics

Program 11-31 04 08 "Computer Physics" is academic education program for students of bachelor level. The program is based on Higher Education Standard OCBO 1-31 04 08-2018. This program is research oriented and started in September 2018, substituting specialists` programs with 5-year term of education.

6.1.SWOT analysis of the curricula

S - the strong sides of the curricula realization

1. The curricula for 4-year bachelor training programme of the Stage I begins education after entering of abiturients to BSU, so that its fulfilling allows one to concentrate on further specialization and proceeding education on Stage II for the master degree preparation.
2. The warranty of succession in the mastering of disciplines on Stage I, which give fundamental knowledge in mathematics and computer physics. The following main components of fundamental education in the field of mathematics and computer science can be singled out:

- mathematical training;
- training in the disciplines of computer physics;
- training in the disciplines of mathematics and applied physics;
- training in the field of computer science and simulating technologies;
- training on special subjects (both in the areas of specialtiy (e.g, teaching, engineering and so on) and within the framework of specializations, the study of which provides the formation of skills for application of acquired mathematical and computer physics knowledge in practice.

Co-funded by the Erasmus+ Programme of the European Union

As a consequence:

- The enough high level of fundamental training in mathematics and simulating techniques in physics to prolong education on the Stage II to get master level;

- The high level of mastering of special disciplines by graduates of the Stage I like "Numerical methods in physics" and "Modern computer algebra systems" and "Database management systems" for the specialty 11-31 04 08 "Computer Physics".

- In general, the training at the Stage I is aimed on preparation of bachelor-level specialists which can work in industrial companies usinf software with the possibility of master-level studies in future.

W - the weak sides of the curricula realization

- Shortening the lecture courses and lab practices for bachelor-level students due to introducing of study practices and the need for preparation of bachelor's diplomas (at conservation of 2 course works, as previously) gives additional risks for the lowering of education quality and demands re-arrangement of lecture courses, laboratory and study practices for their better harmonization between Stages I and II.

- The difficulties in adapting the curricula for foreign students who do not possess the enough high level in Russian language that demands to organize teaching/learning process in English.

O - opportunities outside the university

- Joining to the European Higher Education Area and the Eurasian Economic Union countries, with which the Republic of Belarus have close economic ties and in fact the single job market that enhancs the possibilities for the export of educational services, attracting students from abroad to Belarus.

T - threats of the successful realization of the curricula

- Small experience of Belarusian universities in realization of trainings by Bachelor-level programs that lowers the possibilities for the export of educational services outside Belarus.

- Existing administrative restrictions on the admission on the Stage II of higher education (merely about 7 % per cent of the graduates of the Stage I) does not stimulate the progress of

Co-funded by the Erasmus+ Programme of the European Union

the education on the Stage I and entering graduate to masterships.

- The lack of a clear understanding of the place of graduates with a bachelor degree and their professional duties in industrial and technological sectors, reduces the interest of industrial enterprises to such graduates.

6.2. Type of curricula

The academic educational program 1-31 04 08 "Computer Physics" complies with the educational standard of higher education for the training of specialists of bachelor's level OSVO 1-31 04 08-2018 and was introduced from 2018-09-01.

6.3. Aims and objectives

The main aim of the program is to prepare specialists of bachelor level with competencies in the following fields:

- industry;
- scientific and technical;
- innovative.

The Specialist-Bachelor should be prepared to solve the following tasks of professional activity:

- the study, theoretical analysis of physical effects and phenomena, the establishment of new physical laws based on modern theoretical concepts, mathematical and computer methods;

Co-funded by the Erasmus+ Programme of the European Union

- development on the basis of physical principles of new materials, technologies and devices;

- research work in areas using physical and mathematical methods of analysis and computer technology;

- development of effective mathematical methods for solving problems of technology, economics and management;

- creation and use of mathematical models of processes and objects;

determination of the goals of innovation and methods for their implementation;

- software and information support for design and operational and management activities;

- planning and organization of scientific-industrial, scientific-pedagogical and experimental design work;

- study and analysis of educational systems, the use of educational process in innovation;

- development of educational equipment and scientific and methodological materials for the educational process.Summary

Specialty 1-31 04 08 "Computer Physics" in accordance with OCRB 011-2009 relates to the profile of education G "Natural Sciences", the direction of education 31 "Natural Sciences" and provides получение квалификации «Физик. Программист» of bachelor level.

According to OCRB 011-2009, the specialties are:

- 1-31 04 08 01 Theoretical physics;
- 1-31 04 08 02 Physical informatics;
- 1-31 04 08 03 Computer simulation of physical processes;
- 1-31 04 08 04 Physical metrology and automation of measurements.Learning outcomes

A specialist who has mastered the content of the educational program in the specialty 1-31 04 08 "Computer Physics" should have universal, basic professional and specialized competencies.

Universal competencies

The specialist of Bachelor level who has mastered the content of the educational program

Co-funded by the Erasmus+ Programme of the European Union

in the specialty must have the following universal competencies:

- Know the laws of historical development and the formation of state and public institutions of the Belarusian ethnic group in conjunction with European civilization; be able to analyze the processes of ethnogenesis of the Belarusian nation and the events of the confessional history of Belarus.

- Be able to analyze socially significant phenomena, events and processes, use sociological and economic information, be able to manifest entrepreneurial initiative; be able to determine the goals of innovation and how to achieve them.

- Own a culture of thinking, be able to perceive, generalize and analyze philosophical, ideological and psychological-pedagogical problems in the field of interpersonal relationships and professional activities.

- Own the main categories of political science and ideology, understand the specifics of the formation and functioning of the political system and the peculiarities of the ideology of the Belarusian state.

- Be able to social interaction and interpersonal communications in a foreign language, master the techniques of two-way interpretation and translation of technical literature.

- Possess health care skills.

- Possess basic communication skills in oral and written forms in the Belarusian language for solving problems of interpersonal and intercultural interaction and production tasks.

Professional competencies

The specialist who has mastered the content of the educational program in the specialty must have the following basic professional competencies:

- To own the basic concepts and basic laws of physics, the skills of experimental studies of physical phenomena and processes, basic methods for solving problems of physics.

- Be able to use algebraic and geometrical means, means of mathematical, vector and tensor analyzes to build and solve model problems of applied physics; own the skills of researching functions, calculating their derivatives and integrals.

- To possess the basic concepts of a basic course in computer science, theory of algorithms, the basic constructions of algorithmic languages, technologies of object-oriented programming for solving problems of applied physics, be able to develop software in environments of rapid application development.

Co-funded by the Erasmus+ Programme of the European Union

- Be able to implement basic algorithms and develop programs in modern interpreted programming languages, demonstrate understanding of hardware and software interfaces of information systems.

- Demonstrate the ability to use complex analysis methods in solving physical problems; master the skills of solving ordinary differential equations and partial differential equations.

- Own methods of probability theory and mathematical statistics for processing experimental data and the results of monitoring technological processes; demonstrate the ability to use mathematical physics for modeling and solving standard problems in the field of applied physics.

- Own basic concepts and concepts of the thermodynamic approach to the description of physical systems, possess basic skills in experimental studies of gases, liquids and solids.

- Possess basic concepts and basic laws of electromagnetism, skills of calculations and practical work with electric circuits and devices.

- To be able to apply the basic equations of theoretical mechanics and continuum mechanics to solve applied problems, to have skills in solving practical problems of theoretical mechanics and hydrodynamics in the framework of scientific, technical and industrial activities.

- Own the basic laws and concepts governing the interaction of optical radiation with matter, the laws of wave and geometric optics, methods for solving problems and experimental research of optical systems.

- To possess basic ideas about the electromagnetic properties of materials, methods for solving the problems of electrodynamics and a theoretical description of the fields of charge and current systems

- To be able to interpret the manifestations of wave-particle duality in atomic phenomena, to be able to connect the structure of atomic and molecular systems with their physical and chemical properties.

- Possess the basic laws of the processes of radioactive decay and nuclear reactions; be able to solve the problems of radioactive decay of nuclei, calculate the Q-factor of nuclear reactions and transformations, the binding energy of nuclei.

- Be able to demonstrate knowledge of the laws of thermodynamics and statistical physics, be able to justify thermodynamic laws by the methods of statistical mechanics and solve practically important problems of thermodynamics and statistical physics.

Co-funded by the Erasmus+ Programme of the European Union

- To own the basic laws and basic methods of the theoretical description of quantum-mechanical systems.

- Possess basic methods of protecting production personnel and the public from the negative impacts of anthropogenic, man-made, natural origin factors, knowledge of the basics of rational nature management and energy conservation, legal, organizational and technical fundamentals of ensuring safe and healthy working conditions.

6.4. Duration of the program

Education in the specialty 1-31 04 08 "Computer Physics" provides full-time (full-time, evening) training for students.

The term for higher education in full-time education in the specialty is 4 years.

The term for higher education in evening form is 5 years.

6.5. Study courses and ECTS distribution

Course	Semester	Title of course	Type of work	Quantity of academic hours	Credits
		Theoretical training			
		State component			
		Social and Humanitarian Module-1			
1-3	2-6	History, Economics, Philosophy, Political Science	lectures/seminars	432	12
1-2	1-3	Foreign language	raining practice	308	9
1	1	Mechanics	lectures/labs/ /raining practice	324	9
1	1	Higher mathematics 1 (Mathematical analysis, Analytical geometry and linear algebra, Fundamentals of vector and tensor analysis);	lectures/training practice	540	15
1-2	1-4	Programming (Programming, Software and hardware interfaces of information systems, Introduction to interpreted languages)	lectures/labs/ training practice	214	6

Co-funded by the Erasmus+ Programme of the European Union

1-2	1-3	Higher mathematics 2 (Theory of functions of a complex variable, Differential equations, Probability theory and mathematical statistics, Equations of mathematical physics, Fundamentals of mathematical modeling);	lectures/training practice	868	24
1	2	Molecular physics	lectures/lab. works/training practice	288	8
2	3	Electricity and Magnetism	lectures/lab. works/training practice	342	9
2	3	Theoretical mechanics	lectures/training practice	240	6
2	3	Optics	lectures/lab.works/ training practice	304	8
1	1,2	Electrodynamics	lectures/lab. works/training practice	228	6
1	2	Atom Physics and Nuclear Physics	lectures/lab. works/training practice	464	12
2	3	Thermodynamics and statistical physics,	lectures/training practice	228	6
3	5	Fundamentals of Quantum Mechanics	lectures/ training practice	108	3
		Higher education component			
		Social and Humanitarian Module-2			
		Optional disciplines (elective disciplines (1 of 2))			
3	6	Economics and innovation management, etc. The basics of intellectual property management, etc.	lectures/ training practice	72	2
3	6	Ethnic and confessional history of Belarus, etc. The history of physical ideas, etc.	lectures/ training practice	72	2
		Module "Computer modeling of physical processes"			
2	3-4	Numerical methods in physics		216	6
		Module "Integrated Systems of Data Processing and Modeling"			

Co-funded by the Erasmus+ Programme of the European Union

2	3-4	Modern computer algebra systems	lectures/ training practice	120	3
3	6	Database management systems	lectures/labs	92	3
		Module "Electronics and Quantum Electronics"			
3	6	Fundamentals of Electronics	lectures/labs	120	3
		Optional disciplines (elective disciplines (1 of 2))			
3	6	Introduction to Solid State Electronics. Quantum electronics	lectures/labs	120	3
4	7	**Module "Technical and software experiment"**			
		Optional disciplines (elective disciplines (1 of 2))			
4	7	Digital electronics and others. Laser technology and others.	lectures/labs	92	3
4	7	Automation of the experiment, etc. Computer methods of statistical data analysis, etc.	lectures/labs	92	3
		Specialization disciplines			
3-4	5-7	Disciplines of specialization 1-31 04 08 03 Computer simulation of physical processes	lectures/labs/ seminars	1372	39
3-4	5-7	Subjects of specialization 1-31 04 08 04 Physical metrology and automation of measurement	lectures/labs/ seminars	1372	39
3-4	5-7	Subjects of specialization 1-31 04 08 02 Physical informatics	lectures/labs/ seminars	1372	39
3-4	5-7	Disciplines of specialization 1-31 04 08 01 Theoretical physics	lectures/labs/ seminars	1372	39
2	4	Course work on specialization (abstract nature)		36	1
3	6	Course work on specialization (research character)		72	2
1	2	Programming Practice		1 week	1
4	8	Undergraduate practice		16 недель	24
4	8	Graduate diploma design		4 недели	6

Co-funded by the Erasmus+ Programme of the European Union

6.6. Final assessment

Final certification is carried out by the state examination commission.

Students who have fully completed curriculum and training program are allowed to final certification.

The final certification of students in the development of educational programs in the specialty 1-31 04 08 "Computer Physics" is carried out in the form of a state exam in the specialty, specialization and defense of the diploma work (project).

In preparation for the final certification, the competencies given in the educational standard (see above) are formed or developed.

Requirements for the structure, content, volume and order of defense of the thesis are determined by the institution of higher education on the basis of educational standard and the Rules for the certification of students in the development of the content of educational programs of higher education.

When choosing the topic of the thesis, it is necessary to be guided by the relevance and practical significance of the problem.

6.7. Analysis of the programe for the relevance to the EQF level descriptors

The program is relevant to the Level 6 (ступень бакалавра) of the EQF level descriptors.

During Erasmus project we will do:

Development of new and modernization of having didactic materials for lecture courses, laboratory practices and program trainings.

Notes: (*https://ec.europa.eu/ploteus/en/content/descriptors-page*)

Co-funded by the Erasmus+ Programme of the European Union

3. Francisk Skorina Gomel State University (GSU)

3.1. Summary of training organization

Training process at The Faculty of Physics and Information Technologies of GSU is constructed on the base of flowchart of study stages shown in Table 3.1.

Table 3.1. The study stages at The Faculty of Physics and Information Technologies of GSU

HIGHER EDUCATION FIRST DEGREE (bachelor, diplomaed specialist)	
Speciality	
1-31 04 01 - Physics (in directions) **Qualifications:** - Physicist. Engineer - Physicist. Teacher of physics and informatics **1-31 04 03 - Physical electronics** Qualifications - Physicist-Engineer	**1-31 04 08 - Computer Physics** Qualifications - Physicist. Programmer **1-39 03 01 - Electronic Security Systems** Qualifications - Design Engineer **1-39 03 02 - Programmable Mobile Systems** Qualifications - Systems Engineer **1-53 01 02- Automated data processing systems** Qualifications - IT Engineer
HIGHER EDUCATION SECOND DEGREE (holder of a master's degree)	
Speciality	
1-31 80 05 – Physics (1 year)	**1-45 80 01 Information communications systems and networks (1 year and 8 months)**
PhD STUDENTSHIP (3 years)	
01.04.02-theoretical physics, 01.04.03-radiophysics, 01.04.05-optics, 01.04.07-physics of condensed matter, 01.04.16-physics of atomic nucleus and elementary particles, 05.02.04-friction and wear in machines, 05.16.09-materials science (on branches), 13.00.02-theory and methods of teaching and upbringing (physics, secondary and higher education)	05.13.15 - Computing machines, complexes and computer networks; 05.13.18 - Mathematical modeling, numerical methods and program complexes
PhD in physics and mathematics or PhD in Technical Sciences (in specialities)	

S - the strong sides of the programme realization

Co-funded by the Erasmus+ Programme of the European Union

1 The practical orientation of the programme involving new students - the educated specialists are strongly required in all sectors of economy.
2 The level of the FIRST DEGREE (diplomaed specialist) is high enough.
3 Very good training in fundamental and theoretical physics, engineering performed by experienced and qualified tutors.
4 Strong contacts are established with employers in research institutes and IT.
5 The best students continue the studies at the Master (SECOND DEGREE) and post-graduate courses (PhD STUDENTSHIP).

W - the weak sides of the programme realization
1 Weak co-operation with foreign higher schools that does not allow regularly appoint the students for studies improvement to higher schools abroad.
2 Foreign students can not be attracted to the programme and proper studies due to the lack of English versions of lectures and laboratory practices guides and non-fluency in English of tutors.
3 The laboratory basis is still not modern enough;
4 There is no opportunity to pay for the Specialist work supervising from research institutions and enterprises;
5 There is no space large enough for education the increasing amount of students in the programme;

O - opportunities outside the university
1 To provide co-operation of employers and personnel of the enterprises with students and staff of the programme;
2 The development of the Specialist diploma work promotes consolidation of higher schools scientific potential and co-operation with research institutes and IT enterprises;
3 To allow to employers to evaluate young specialists and select them at the stage of studies;
4 To give an opportunity to involve the international funds to the purchasing of training equipment as well as improvement of laboratory practice realization.

T - threats of the successful realization of the programme
1 Not enough training equipment for laboratory practices for the existing number of students;
2 The tutors are overloaded and there is no possibility to decrease the load because of the decreasing financing from the state budget;
3 Difficulties with attracting of the paying students because of uncertain situation with labour market and economy development;
4 High student dropout because of unsuccessful studies or other reasons (sabbatical leaves);
5 Decreasing budget financing.

Co-funded by the Erasmus+ Programme of the European Union

Types of Education Plans for the first and second degree of higher education in GSU you can see in table 3.2 and 3.3.

Table 3.2. Types of Education Plans for the first degree of higher education in GSU

N N	Education plan (speciality code, directions)	Education standard
1	1-31 04 01-02 – Physics (production activity)	1-31 04 01 -2013 № 88 from 30.08.2013
2	1-31 04 01-03 – Physics (scientific and pedagogical activity)	1-31 04 01 -2013 № 88 from 30.08.2013
3	1- 31 04 03 - Physical electronics	1-31 04 03 -2013 № 87 from 30.08.2013
4	1-53 01 02- Automated data processing systems	1-53 01 02 -2013 № 88 from 30.08.2013
5	1-39 03 01 - Electronic security systems	1-39 03 02 -2013 № 88 from 30.08.2013
6	1-39 03 02 - Programmable Mobile Systems	1-39 03 02 -2013 № 88 from 30.08.2013
7	1-31 04 08 - Computer Physics	1-31 04 08 -2018 № 124 from 22.12.2018

N N	Speciality code, directions	Standard study plan	Study plan
1	1-31 04 01-02 – physics (production activity)	G 31-1-018/тип. from 28.06.2013	Approved by the rector of GSU G 31-03-13 from 29.08.2013
2	1-31 04 01-03 – physics (scientific and pedagogical activity)	G 31-1-019/тип. from 28.06.2013	Approved by the rector of GSU G 31-02-18 from 21.03.2018
3	1- 31 04 03 - Physical electronics	G 31-1-043/тип. from 26.07.2013	Approved by the rector of GSU G 31-05-13 from 29.08.2013
4	1-53 01 02- Automated data processing systems	I 53-1-001/тип. from 30.05.2013	Approved by the rector of GSU I 53-01-18 from 21.03.2018
5	1-39 03 01 - Electronic security systems	I 39-1-015/тип. from 30.11.2013	Approved by the rector of GSU I 39-02-15 from 28.01.2015
6	1-39 03 02 - Programmable Mobile Systems	I 39-1-010/тип. from 30.05.2013	Approved by the rector of GSU I 39-01-15 from 28.01.2015
7	1-31 04 08 - Computer Physics	G 31-1-007/пр-тип. from 12.07.2018	Approved by the rector of GSU G 31-01-18 from 17.07.2018

Co-funded by the Erasmus+ Programme of the European Union

Table 3.3. Types of Education Plans for the second degree of higher education in GSU

N N	Education plan (speciality code, directions)	Education standard
1	1-31 80 05 – Physics (1 year)	1-31 80 05 -2019 № 81 from 26.06.2019
2	1-45 80 01 Information communications systems and networks (1 year and 8 months)	1-45 80 01 -2019 № 155 from 23.09.2019

N N	Speciality code, directions	Standard study plan	Study plan
1	1-31 80 05 – Physics (1 year)	G 31-2-005/пр-тип. from 21.03.2019	Approved by the rector of GSU G 31-2-02/D-19 from 09.04.2019
2	1-45 80 01 Information communications systems and networks (1 year and 8 months)	I 45-2-001/пр-тип. from 26.03.2019	Approved by the rector of GSU I 45-2-01/D-19 from 09.04.2019

3.2. Specialist academic educational bachelor programme "1-31 04 01 - Physics (in directions)"

Overall objectives of training:

- formation and development of socio-professional, practice-oriented expertise, allowing to combine academic, personal-social, professional competence for solving problems in the field of professional and social activities;
- formation of professional competencies for theoretical and experimental work aimed at the study, analysis and practical application of physical processes in various fields of production activity, including the improvement and development of new physical approaches in order to solve modern problems of science and technology, energy, production.

The sphere of professional activity of a specialist

The main spheres of professional activity of a specialist are:

- Scientific research and development;
- Education.

The objects of professional activity of a specialist

The objects of professional activity of the expert are: the physical laws, hypotheses, theorems, mathematical models and methods in the study of physical objects and processes; instrumentation and process equipment; and measuring technological complexes and automation systems used in physical experiments, the production of materials and devices; the educational system, pedagogical process, scientific and methodological support of disciplines of physics and mathematics.

Types of professional activity of a specialist

The specialist must be competent in the following activities:

- research;
- production;

Co-funded by the Erasmus+ Programme of the European Union

- scientific-pedagogical;
- management.

Tasks of professional activity of a specialist

The specialist should be prepared to address the following professional tasks:
- the study, the theoretical analysis of physical effects and phenomena, the introduction of new physical laws based on modern theoretical concepts, mathematical and computer methods;
- development of new materials on the basis of physical principles, technologies and devices;
- research work using physical and mathematical methods of analysis and computer technologies;
- development of effective physical and mathematical methods for solving problems in technology, economy and management;
- creating and using mathematical models of physical processes and objects;
- defining new goals and ways of their implementation;
- software and information support to perform design, operational and management activities;
- planning and organization of academic, production, research and development activities;
- study and analysis of educational systems, the use of innovation processes in education; development of training equipment and methodological materials for the educational process.

During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses and laboratory practices.

3.3. Specialist academic educational bachelor programme 1-31 04 03 - Physical electronics

Overall objectives of training:

- the formation and development of socio-professional, practice-oriented expertise, allowing to combine academic, personal-social, professional competence for solving problems in the field of professional and social activities;
- the formation of professional competencies to work in Physical electronics, including the use of computer technologies.

The sphere of professional activity of a specialist:

The main spheres of professional activity of a specialist are:
- Manufacture of computing, electronic and optical equipment;
- Production of electrical equipment;
- Telecommunications Activities;
- Computer programming, consulting and other related services;
- Information service activities;
- Scientific research and development.

The objects of professional activity of a specialist:

- physical processes and phenomena associated with the interaction of electrons and ions,

located in vacuum, gases, solids and solid structures with electromagnetic fields;

- principles of functioning and methods for creating various kinds of electronic

devices, integrated circuits, devices and systems used for the transmission, reception, processing and storage of information;

- physical properties of materials and active media of electronics;

Co-funded by the Erasmus+ Programme of the European Union

- methods and means of research, as well as monitoring these properties;
- electronic devices, integrated circuits, devices, analytical and technological equipment using automated data recording and processing systems;
- technology for the production of electronics and radio electronics;
- models and software for solving typical problems of vacuum, solid-state, micro- and nanoelectronics.

Types of professional activity of a specialist:
The specialist must be competent in the following activities:
- research;
- production;
- design;
- management;
- innovative.

Tasks of professional activity of a specialist:
The specialist should be prepared to address the following professional tasks:
- dealing with problems requiring the application of fundamental knowledge in Physical electronics as an independent branch of knowledge including the study and application of processes and phenomena associated with the interaction of electrons and ions in vacuum, gases, solids and solid structures with electromagnetic fields, as well as the development of functioning guidelines and methods for creating various kinds of electronic devices, integrated circuits, devices and systems for all areas of modern electronics, microelectronics and nanoelectronics;
- study of physical processes and phenomena that determine the principles of functioning and production technology of instruments, integrated circuits and devices on their basis, for all areas of modern electronics, microelectronics and nanoelectronics
- study of the physical properties of materials, active media as well as processes and phenomena occurring in these media in order to create materials of electronic equipment and nanomaterials with new unique properties;
- development of new advanced electronic devices, integrated circuits, systems and technological processes, as well as implementation of new developments;
- development of mathematical models and software for the description and analysis of physical processes and phenomena, as well as the modernization of instruments, devices, systems and technologies;
- development of models and software to automate the design of new devices, integrated circuits and technological processes;
- improvement and dissemination of research methods used in Physical electronics into other fields of scientific research and applications;
- staff training and development;
- assessment of results, including the feasibility study of technological processes and production activities.

During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses and laboratory practices.

Co-funded by the Erasmus+ Programme of the European Union

3.4. Specialist academic educational bachelor programme 1-39 03 02 - Programmable Mobile Systems

Overall objectives of training:
- the formation and development of socio-professional, practice-oriented expertise, allowing to combine academic, personal-social, professional competence for solving problems in the field of professional and social activities;
- the formation of professional competencies to work in the field of hardware and software, maintenance and consulting of mobile electronic systems.

The sphere of professional activity of a specialist:
The main spheres of professional activity of a specialist are:
- Computer hardware, electronic and optical equipment production;
- Telecommunications Activities;
- Computer programming, consulting and other related services;
- Information service activities;
- Engineering design and technical advice in this area;
- Research and development in technical sciences.

The objects of professional activity of a specialist:
- Programmable mobile systems as a whole;
- Component functional parts of programmable mobile systems, including specialized electronic computer devices (microprocessors), which are built into the hardware of the system and which supplement the system's functions in terms of processing information and generating control commands, as well as programming technology embedded into mobile systems of microprocessor devices and computer subsystems.

Types of professional activity of a specialist:
The specialist must be competent in the following activities:
- design;
- production;
- installation and set-up;
- repair and maintenance;
- management;
- research;
- expertise and advice;
- education;
- innovative.

Tasks of professional activity of a specialist:
The specialist should be prepared to address the following professional tasks:
- design of conventional and innovative programmable mobile systems designed to monitor and control the state of objects and processes in industry, transport, economy, security sector, etc.;
- analysis of objects and processes in terms of controlling and managing their conditions, as well as defining goals and objectives of a programmable mobile system;
- development of a structural diagram and algorithm for the operation of a programmable

Co-funded by the Erasmus+ Programme of the European Union

mobile system taking into account the goals and objectives;
- definition of the functions performed by the constituent parts of the system and the distribution of these functions between the radio electronic parts and programmable specialized electronic computer devices (microprocessor technology, computer subsystems) embedded in the mobile system;
- characterization of electronic devices used as part of the system (signal generation devices, signal monitoring and reception devices, control signal generation devices, etc.), selection of circuit solutions;
- characterization of microprocessor technology and computer subsystems embedded in the hardware of an electronic mobile system, development of an algorithm for their operation as part of a mobile system and programming;
- selection and design of information transmission channels to ensure interconnection and interaction between hardware (circuitry) and programmable parts of a mobile system: wired, fiber-optic, telecommunication, including satellite;
- layout of the hardware parts of a programmable mobile system, considering its mobility, the nature of the tasks solved by the system, and the user capabilities;
- organization and control of development, debugging and testing of mobile system software;
- development of rules for the operation of a programmable mobile system and recommendations for maintaining the operability of its hardware and software parts;
- carrying out scientific and experimental work dealing with the use of programmable mobile systems to solve problems on monitoring the state and managing objects and processes of various nature (automobile and railway transport, border and customs control, etc.);
- education and training of specialists in the field of software development for mobile systems;
- feasibility study on the effective implementation of programmable mobile systems;
- development and implementation of new methods to ensure the monitoring of objects (their state and management) and processes using programmable mobile systems and telecommunication channels, including satellite.

During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses and laboratory practices.

3.5. Specialist academic educational bachelor programme 1-39 03 01 - Electronic Security Systems

Overall objectives of training:
- formation and development of socio-professional, practice-oriented expertise, allowing to combine academic, personal-social, professional competence for solving problems in the field of professional and social activities;
- formation of professional competencies to work in the area of creation and operation of both conventional and innovative intelligent electronic security systems for facilities, territories and personnel (individuals).

The sphere of professional activity of a specialist:
The main spheres of professional activity of a specialist are:
- Manufacture of computing, electronic and optical equipment;
- Software Edition;

Co-funded by the Erasmus+ Programme of the European Union

- Telecommunications Activities;
- Computer programming, consulting and other related services;
- Computer programming activities;
- Information service activities;
- Engineering design and technical advice in this area;
- Technical testing, research, analysis and certification;
- Research and development in the field of natural and technical sciences;
- Higher education.

The objects of professional activity of a specialist:
- processes for identifying threats and risks for facilities and individuals;
- Electronic Security Systems (ESS) as a whole (including innovative and intelligent electronic security systems, as well as their hardware and software subsystems) that perform the functions of protecting facilities from unauthorized entry, ensuring the safety of facilities and individuals;
- software development and debugging processes for information-computer subsystems and microprocessor devices operating as part of the ESS;
- processes of installation, set-up and maintenance of ESS for any facilities (of civil, industrial, special purpose, transport, etc.) where there is a need to protect against unauthorized entry to facilities, ensure information, environmental and other types of security.

Types of professional activity of a specialist:
The specialist must be competent in the following activities:
- design;
- production;
- installation and set-up;
- repair and maintenance;
- management;
- research;
- expertise and advice;
- education;
- innovative.

Tasks of professional activity of a specialist
The specialist should be prepared to address the following professional tasks:
Integrated design of ESSs, innovative ones among them, for civil, industrial and special purpose facilities, as well as for protecting personnel (individuals) from emerging threats, including:
- identification of threats and risks for the facility or personnel, development of the ESS block diagram;

Co-funded by the Erasmus+ Programme of the European Union

- the list and characterization the used technology items (sensors, detectors, converters, information and computer subsystems, control panels, actuating devices, etc.), the choice of their types and programming;
- organization of interconnection between radio engineering, electronic-optical, electronic-computing and other parts of the system, as well as ensuring compatibility of the ESS with the installation facility, the external environment and the operator;
- selection and design of information transmission channels to ensure interconnection and interaction between parts of the electronic security system and the operator (wired, fiber-optic, telecommunication, including satellite);
- design of electrical circuits and subsystems based on microprocessor technology and computers embedded in ESS, and programming of these subsystems in accordance with the solution of tasks assigned to the security system;
- programming of information and computer subsystems which operate as part of intelligent and conventional ESSs;
- layout (placement) of the ESS parts at the facility, taking into account the characteristics of the facility itself, the nature of the tasks being solved by the system, and the operators' capabilities;
- reliability assessment of the ESS functional parts and forecasting (calculation) of the performance indicator of the security system as a whole;
- organization and on-site control of set-up and maintenance of electronic devices and ESS in general;
- organization and management of ESS operation processes, including intelligent electronic security systems;
- research and experimentation connected with the creation of innovative electronic systems to ensure the safety of facilities and individuals;
- education and training of specialists in ESS design and operation for various functional purposes, including intelligent security systems;
- feasibility analysis of the efficiency of ESS usage at the installation facilities;
- development and implementation of new methods, satellite data transmission channels, information technology advances in creating innovative ESS;
- consultations on the ESSs operation for various functional purposes, consultations on the design and manufacture of their hardware and on the development of software that implements the functioning algorithms of security systems.

During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses and laboratory practices.

3.6. Specialist academic educational bachelor programme 1-31 04 08 - Computer Physics

Overall objectives of training:

- formation and development of socio-professional, practice-oriented expertise, allowing to combine universal, basic professional, specialized competencies to solve problems in the field of professional and social activities;

Co-funded by the Erasmus+ Programme of the European Union

- carrying out theoretical and experimental work aimed at the study, analysis and practical use of physical theories, processes, methods and technologies in various fields of production, including the improvement and development of new physical approaches in order to solve modern problems of science and technology, energy, production;
- planning and organization of experimental design work in various fields of industry and energy;
- solution of engineering problems and implementation of the results in the technological field.

The sphere of professional activity of a specialist:

The main areas of professional activity of a specialist are:
- Research and development;
- Education.

Objects of professional activity of a specialist

The objects of professional activity of a specialist are software, mathematical models and methods for modeling physical objects and processes; technological and measuring complexes and automation systems used in physical experiments, production of materials and devices; physical laws, hypotheses, theorems; measuring and technological equipment; physical control methods in combination with mathematical modeling methods; economic and social laws, educational systems, pedagogical processes, educational and methodological support of physical and mathematical disciplines.

Types of professional activity of a specialist

The specialist must be competent in the following activities:
- production;
- scientific and technical;
- innovative.

Tasks of professional activity of a specialist

The specialist should be prepared to solve the following professional problems:
- the study, theoretical analysis of physical effects and phenomena, the introduction of new physical laws based on modern theoretical concepts, mathematical and computer methods;
- development of new materials on the basis of physical principles, technologies and devices;
- research work using physical and mathematical methods of analysis and computer technologies;
- development of effective mathematical methods for solving problems in technology, economics and management;
- creating and using mathematical models of physical processes and objects;
- defining new goals and ways of their implementation;
- software and information support to perform design, operational and management activities;
- planning and organization of academic, production, research and development activities;
- study and analysis of educational systems, the use of innovation processes in education;
- development of educational equipment and scientific and methodological materials for the educational process.

Co-funded by the Erasmus+ Programme of the European Union

During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses and laboratory practices.

3.7. Specialist academic educational bachelor programme 1-53 01 02- Automated data processing systems

Overall objectives of training:
- formation and development of socio-professional, practice-oriented expertise, allowing to combine academic, personal-social, professional competence for solving problems in the field of professional and social activities;
- formation of professional competencies to work in the field of automated data processing systems, consulting and other related services, as well as activities in the field of information services and management.

The sphere of professional activity of a specialist:
The main spheres of professional activity of a specialist are:
- information technology and information service activities;
- computer programming, consulting and other related services;
- research and development;
- higher education.

The objects of professional activity of a specialist:

The objects of professional activity of a specialist are: automated information systems, workstations, computer networks for various purposes, systems and services for automating production, economic, organizational and managerial activities in industrial, transport, agricultural and other enterprises and organizations, as well as in educational and R&D institutions.

Types of professional activity of a specialist:
The specialist must be competent in the following activities:
- production;
- design;
- installation and set-up;
- repair and maintenance;
- expertise and advice;
- research and education;
- management.

Tasks of professional activity of a specialist:
The specialist should be prepared to address the following professional tasks:
- data collection and analysis, target-setting for automation of various kinds of activities and functions;
- development and selection of effective methods to solve problems related to the presentation, storage, displaying, transmission and analytical processing of data;
- development, administration and effective operation of data processing systems based on

Co-funded by the Erasmus+ Programme of the European Union

modern database management systems;
- organization, development, installation, testing and maintenance of application and system software;
- administration, setup and operation of local and global computer networks and data processing systems based on these networks;
- system analysis and decision making based on mathematical and simulation modeling using deterministic, probabilistic and statistical methods;
- staff training.

During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses and laboratory practices.

3.8. Specialist academic educational master programme 1-45 80 01 Information communications systems and networks (second degree)

The sphere of professional activity of a specialist with Master's degree

Higher education;
Research and development;
Broadcasting;
Telecommunications Activities.

The objects of professional activity of a specialist with Master's degree:
- telecommunication transport networks;
- access systems and networks;
- information and communication services;
- information and communication management systems and networks;
- information and communication network protection systems;
- software for information and communication systems and networks;
- radio communication systems and networks;
- optical systems and data networks;
- computer networks;
- television systems;
- television and sound broadcasting systems and networks.

Types of professional activity of a specialist with Master's degree:
The specialist must be competent in the following activities:
- education;
- research;
- innovative;
- design.

Tasks of professional activity of a specialist with Master's degree:
The specialist should be prepared to address the following professional tasks:
- organization of curriculum framework and educational activities, as well as practical and laboratory classes based on equipment of info-communication systems and networks;

Co-funded by the Erasmus+ Programme of the European Union

- creation, management and use of complex information and communication systems;
- effective teamwork of designers and developers of information and communication systems and networks;
- planning and time management;
- organization, planning and implementation of research and development of information and communication systems;
- areas, methods and research tools selection;
- development of technical specifications and research programs;
- assessment of the completeness and accuracy for achieving the objectives defined, as well as the evaluation of perceived competitiveness, technical and economic efficiency of research objects;
- substantiation of the scientific and technical level of the development object;
- research report-writing, preparation of reports and scientific presentations, writing articles for scientific journals;
- training, conducting and participating at a high professional level in info-communication seminars;
- the use of a wide range of skills and multidisciplinary knowledge in the field of info-communications to solve scientific, technical and innovative issues in the academic and info-communication environment.

During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses and laboratory practices.

3.9. Specialist academic educational master programme 1-31 80 05 – Physics (second degree)

The sphere of professional activity of a specialist with Master's degree
– Production of electrical equipment;
– Research and development;
– Education.

The objects of professional activity of a specialist with Master's degree
- laws of physics, hypotheses, theorems;
- mathematical models and research methods of physical objects and processes;
- measuring and technological equipment;
- technological and measuring complexes and automation systems used in physical experiments and production of materials and devices;
- educational systems, educational process, educational and methodological support of physical and mathematical disciplines.

Types of professional activity of a specialist with Master's degree:
The specialist must be competent in the following activities:
- education and methodology;
- research;
- production;
- management;
- innovative.

Co-funded by the Erasmus+ Programme of the European Union

Tasks of professional activity of a specialist with Master's degree:

The specialist should be prepared to address the following professional tasks:

- preparation and delivery of courses in physics and mathematics in institutions of specialized secondary and higher education, research management and guidance, development of educational and methodological support of the educational process;
- planning and conducting experimental and theoretical research in physics and technology;
- preparation of practical guides on the use of achievements of physics and advanced technologies in industry and education, the study of patentability and indicators of the technical development level, the development of scientific and technical documentation;
- the use of modern design methods, automation of a physical experiment, the production of materials and devices;
- analysis of the economic activity of enterprises operating in high-tech industry;
- development of plans and programs for organizing innovative activities, a feasibility study of innovative projects in professional activities.

During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses and laboratory practices.

Co-funded by the Erasmus+ Programme of the European Union

Table 3.4. New courses and courses to be updated

	Title of course	Type of work	Quantity of academic hours	Reporting form	ECTS	Level of study
New courses						
1.	Fundamentals of business and legislation in IT	Lectures Labs	34 42	exem	4	Bachelor, masters
2.	Theoretical Mechanics	Lectures Labs	60 60	exem	4	Bachelor, masters
3.	Analytical modelling of friction and wear processes	Lectures Labs	32 10	exem	4	Bachelor, masters
4.	Simulation of the interaction of electromagnetic waves with DNA-like helices	Lectures	32 10	exem	4	Bachelor, masters
5.	Technologies of laser treatment of materials	Lectures Labs	36 12	exem	4	Bachelor, masters
6.	Modelling of microwave and THz devices based on metamaterials	Lectures Labs	32 10	exem	4	Bachelor, masters
7.	Simulation of surface charge distribution in nanostructured materials	Lectures Labs	32 10	exem	4	Bachelor, masters
8.	Practical statistics for physicists	Lectures Labs	32 10	exem	4	Masters
9.	Hardware and software of networks	Lectures Labs	46 34	set-off	4	Bachelor, masters
10.	Microprocessors and microcontrollers	Lectures	76 70	exem set-off	4	Bachelor, masters
Courses will be updated						
1.	Computer simulation of physical systems and processes	Lectures Labs	50 50	exem	6	Bachelor, masters
2.	Computer systems of analytical calculations	Lectures Labs	20 34	exem	3	Bachelor, masters

Co-funded by the Erasmus+ Programme of the European Union

Table 3.5. Analysis of the new programes for the relevance to the EQF level descriptors

	Title of course	EQF level descriptors
1.	Fundamentals of business and legislation in IT	7
2.	Theoretical Mechanics	7
3.	Analytical modelling of friction and wear processes	7
4.	Simulation of the interaction of electromagnetic waves with DNA-like helices	7
5.	Technologies of laser treatment of materials	7
6.	Modelling of microwave and THz devices based on metamaterials	7
7.	Simulation of surface charge distribution in nanostructured materials	7
8.	Practical statistics for physicists	7
9.	Hardware and software of networks	7
10.	Microprocessors and microcontrollers	7

Table 3.6. Analysis of the updated programes for the relevance to the EQF level descriptors

	Title of course	EQF level descriptors before upgrade	EQF level descriptors after upgrade
1.	Computer simulation of physical systems and processes	5	7
2.	Computer systems of analytical calculations	5	7

The Wolfram Mathematica is a complete integrated and constantly expanding system that covers the breadth and depth of analytical, numerical and technical calculations.
Wolfram Mathematica has access to a broad Wolfram Knowledge base that includes up-to-date real-world data from thousands of subject areas.
Therefore, the purchase of licensed Wolfram Mathematica software to study such subjects as «Computer simulation of physical systems and processes» and «Computer systems of analytical calculations» will allow students to improve their knowledge and skills, as well as to expand their level of responsibilities.
In particular, it will provide advanced knowledge, necessary to solve complex and unpredictable problems when evaluating physical problems using a computer, and will allow you to master the skills and responsibilities that require decisions during learning or unpredictable work processes.

(***https://ec.europa.eu/ploteus/en/content/descriptors-page***)

Co-funded by the Erasmus+ Programme of the European Union

4. Mozyr State Pedagogical University (MSPU)

4. Mozyr State Pedagogical University (MSPU)

4.1. SWOT analysis of the institution

S – the strong sides of the institution

1. Positive reputation of the University in the Republic of Belarus and abroad as an educational establishment which specializes in teachers' training;
2. Compliance with deep pedagogical traditions and innovations in teaching;
3. Accredited bachelor/ master's/ PhD programs;
4. Certificate of conformity attesting the quality management system of MSPU which conforms to the requirement of STB ISO 9001-2015 (BY/112 05.01.002 02480) and Quality management system certificate given by BelGISS (QMS-00098);
5. Highly experienced, strong and dedicated teaching staff; 55% of teachers have got academic degrees (PhDs and doctor's degrees) and ranks (associate professors and professors);
6. High rates of employment among University graduates in the home country and abroad;
7. Successful acknowledgement of the diploma of Higher Education by foreign alumni in their home countries;
8. Reasonable tuition fees charged from Belarusian and foreign students;
9. Provision with a room in the student dormitories of the University;
10. Geographic growth of countries with regard to international cooperation and foreign students' recruitment;
11. Increase of academic mobility;
12. Good professional practice in EU-funded projects;
13. Support programs for talented students;
14. The best bachelor degree students get a master's degree and then a PhD course;
15. Employment of MSPU graduates to educational establishments located in the regions suffered from the Chernobyl's disaster.

W – the weak sides of the institution

1. Geographical location of the University ("status of the provincial university");
2. Weak correspondence to Bologna principles with regard to modernization of Higher education;
3. English is not the language of instruction;
4. Low attraction of studies at the University for foreign students who want to get a degree, because most subjects are taught in Russian;
5. Not modern laboratories and language labs for students;
6. Not enough financial resources for new and well-equipped classrooms and laboratories;
7. Not enough space for new classrooms/hub/clubs/labs;

Co-funded by the Erasmus+ Programme of the European Union

8. Decrease of applicants (prospective first year students) because of the demographic pitfall of the 1990-es;
9. Low academic achievements of school leavers who enter Pedagogical universities;
10. Poor building infrastructure;
11. Weak competence in English language teaching;
12. Lack of strategic vision and skills for successful marketing practices.

O – opportunities for the institution

1. Modernization of the content of bachelor degree programs;
2. Equipage of MSPU labs with up-to-date hardware and software;
3. Development of international cooperation in the field of science and research;
4. Development of academic mobility for teachers and students;
5. Advanced training of MSPU teachers and their professional upgrade;
6. Introduction of the best teaching practices into the educational process;
7. Provision of new knowledge and compliance with modern requirements of the labour market to graduates;
8. Upgrade of hard skills and soft skills of MSPU graduates;
9. Positive effect on the image of the university and attraction of pedagogical education in the society;
10. Strengthening of MSPU's position in the world scientific community;
11. Lecturing in English and increase of bachelor/master's/ PhD programs taught in L2;
12. Supply of highly-qualified workers and enhancement of economic sector in Gomel region;
13. Establishment of better links with the employers.

T – threats of the institutions

1. Decrease in quantitative indices of local and foreign students;
2. Competitive weakness of the University;
3. Gaps in the latest technologies, best teaching practices and tools between MSPU and the universities in Minsk and Gomel.

4.2. Type of study program

4.2.1. Type of study program: 1-31 04 08 "Computerized Physics"

Study program 1-31 04 08 "Computerized Physics" was developed in accordance with the national classification code of the Republic of Belarus 011-2009. The program belongs to Section D "Natural Sciences", Direction 31 "Natural Sciences". This program corresponds to EQF level 6. Qualification "Physicist. Software developer" is conferred after the completion of the program. In accordance with the national classification code of the Republic of Belarus 011-2009 Specialization 1-31 04 08 03 "Computer generated simulation of Physical processes" has been added.

4.2.2. Type of study program: 1-02 05 02 "Physics and Informatics"

Study program 1-02 05 02 «Physics and Informatics» was developed in accordance with the national classification code of the Republic of Belarus 011-2009. The program

Co-funded by the Erasmus+ Programme of the European Union

belongs to Section A "Pedagogics", Direction 02 "Pedagogics of juvenile and adolescence ages". Qualification "Teacher". This program corresponds to EQF level 6.

4.3. Aims and objectives

4.3.1 Aims and objectives : 1-31 04 08 "Computerized Physics"

The overall aims are as follows:

- to form and develop social and professional, practice-oriented competences;
- to compound all-round, basic, professional and specialized competences for solution of practical tasks in career and social activities;
- to investigate, analyze and apply to Physical theories, processes, methods and techniques in various fields of industrial activity;
- to enhance and develop new approaches of Physics for solution of tasks in the field of Science, Technology, Energetics, Industry;
- to plan and arrange research and development work in Industry and Energetics;
- to develop competence for solution of tasks in Engineering, Physics, Technology.

The objectives are as follows:

- to study and analyze Physical effects and phenomena;
- to establish new Physical principles on the ground of modern theoretical ideas, mathematical and computerized methods;
- to develop new material, technologies and equipment on the ground of Physical principles;
- to conduct research using methods of Physics, Mathematics, IT;
- to develop effective methods of Mathematics for further solution of tasks in Engineering, Economics and Management;
- to create and use mathematical models of processes and objects;
- to determine the aims of innovation and ways how to apply to them;
- to arrange design-and-engineering and operation-and-managerial activities;
- to plan and arrange research and industrial, science and research, development work;
- to make projects, contract, invoices, reports and other documentation;
- to study and analyze educational systems;
- to apply to innovative teaching techniques while studying;
- to develop equipment for studies;
- to develop research and methodology tools for educational process.

4.3.2 Aims and objectives: 1-02 05 02 "Physics and Informatics"

The overall aims are as follows:

- to form and develop social, professional, practice-oriented competencies;
- to use a combination of academic, social, personal, professional competencies when the tasks are solved in profession and other social affairs;
- to form professional competencies which will allow to implement educational, training, developing, value-oriented activities;
- to form professional-pedagogical competencies for further management of overall pedagogical process with regard to modern technologies and innovations.

Co-funded by the Erasmus+ Programme of the European Union

The objectives are as follows:
- to manage educational, cognitive, study and research activities ;
- to regulate the relations and cooperation in the educational process;
- to use optimized methods, forms, means of studies, training, education;
- to arrange the lessons and educational activities;
- to develop skills for individual work of students;
- to develop basic components of students' personal culture.

4.4. Summary

4.4.1. Summary: 1-31 04 08 "Computerized Physics"

1-31 04 08 "Computerized Physics" is a study program for bachelor degree students held at the premises of Physics and Engineering Department. The students majoring in the field are to complete the courses included in the State component and University component of the study plan, undertake practical training and on-job-training and prepare a Diploma engineering project. When the tuition period is completed a student gets a status of a specialist. Science, research, education are the areas of professional expertise.

The objects of professional activities are selected as follows: computational hardware and software, mathematical models and methods for modeling of physical objects and processes, technological complexes for experiment and systems of automation used to conduct physical experiment, production of material and equipment; laws of Physics, hypothesis, theorems; measuring equipment and technological equipment; Physical methods for mathematical modelling; economic and social regularities, educational systems, teaching processes, academic and methodology supply of the disciplines included in the cycle of Physics and Mathematics.

Production, research, technology and innovation are the activities a specialist will implement in his/her career.

A specialist must be well prepared for solution of the following professional objectives:

- to study theoretical analysis of physical effects and phenomena, to establish new physical regularities on the basis of modern theoretical views, mathematical and computerized methods;
- to develop new manuals, technologies and tools on the basis of physical principles;
- to conduct research in the field of Physics, Mathematics and IT;
- to develop effective mathematical methods for solutions of tasks in technologies, economics and managements;
- to create and apply to mathematical models and processes and objects;
- to determine the aims of innovations and methods of implementation;
- to provide programming and informational supply of project-construction and managerial activities;
- to plan and arrange the activities in the field of research, industry, teaching and construction;
- to make up projects, contracts, invoices, reports;
- to study and analyze educational systems;
- to apply to innovations in the academic process;

Co-funded by the Erasmus+ Programme of the European Union

- to develop equipment and manuals for studies and education.

A specialist who completed this study program successfully and in full is allowed to continue studies and professional and scientific upgrade in the related fields of Master's degree programs.

4.4.2. Summary: 1-02 05 02 "Physics and Informatics"

1-02 05 02 "Physics and Informatics" is a study program for bachelor degree students held at the premises of Physics and Engineering Department. Training in the field "Physics and Informatics" is expected to form definite professional competencies, included knowledge and skills for arrangement and management of academic and cognitive, research and other types of activities of the students; to regulate the relations and cooperation while educating; to use optimized methods, forms and means of education and training; to hold lessons and educational events; to form basic components of student's personality. Moreover, much attention is paid to formation of skills and knowledge in research and theoretical analysis of physical effects and phenomena; establishment of new regularities in Physics on the basis of modern theoretical views, methods of Mathematics, computerized methods; development of new materials, technologies and tools on the basis of physical principles; development of effective methods of Mathematics and Physics for solution of tasks in the field of Engineering, Economics, Management; creation and use of mathematical models of Physical processes and objects; software and information supply of drawing-and-designing and operational-managerial affairs; planning and organization of research and production, development and teaching activities; study and analysis of the educational system; use of innovations in the educational process; development of equipment for studies and research-and-methodology materials for educational process.

4.5. Learning outcomes

4.5.1 Learning outcomes: 1-31 04 08 "Computerized Physics"

Learning outcomes are measured and evaluated by the quality of competences achieved by the students who have completed the program 1-31 04 08 "Computerized Physics" in full. The competences are divided into 3 groups: broad based competences, professional competences, specialized competences.

A student who has completed the full program must obtain the following broad based competences:

- to know regularities of historical development and to form State and Public institutes of Belarusian ethnicity and its correlation with European civilization;
- to analyze the processes of ethno genesis of the Belarusians and the events of confessional History of Belarus;
- to analyze socially important phenomena, events, processes;
- to use sociological and economic data;
- to be capable to create entrepreneurial initiative;
- to know how to determine the aims of innovation and the ways to achieve them;
- to be capable for mental activity;

Co-funded by the Erasmus+ Programme of the European Union

- to have the ability for comprehension, generalization and analysis of philosophical, worldview and psychological-pedagogical tasks in the field of interpersonal relations and professional activity;
- to know basic categories in political sciences, ideology;
- to understand the specific features of how political system is formed and functioned;
- to know the peculiarities of the ideology of the Belarusian state;
- to be capable for social and interpersonal communication in a foreign language;
- to translate and interpret technical literature;
- to develop skills for health-saving technologies;
- to have basic skills for oral and written communication in Russian/Belarusian with the aim to solve interpersonal and intercultural cooperation and production targets;
- to be capable for searching, systematization and analysis of patent information and actions to protect intellectual property;
- to show skills for retrospective analysis of Physical ideas and engineering solutions, further use of the obtained results in the career;
- to be capable to search and analyze scientific data, reference data.

A student who has completed the full program must obtain the following professional competences:

- to know basic notions and laws of mechanics, skills for experiments and research of mechanical phenomena and processes, basic methods for solution of tasks in Mechanics;
- to be capable to use methods of Algebra and Geometry, skills for mathematical, vector and tensor analysis when model tasks in Applied Physics are solved, to have skills for research, derivation and integral equations;
- to have basic knowledge of IT, Theory of algorithms, basic constructions of algorithmic language, technologies for object-oriented software development for the purpose to solve the tasks of Applied Physics, to know how to develop software for applications;
- to be able to develop basic algorithms and develop software, to show understanding of hardware-and-software interface;
- to show skills for comprehensive analysis when tasks in Physics are solved, to have skills for solution of differential equations, differential coefficients;
- to be aware of methods of laws of probability and mathematical statistics for processing of empirical data and results of monitoring of technological processes;
- to know and understand basic notions and overview of thermodynamic approach to Physical systems, to have basic skills for research tests of gas, liquid and solid objects;
- to know basic terms and laws of electromagnetics, to have skills for calculation and work with electric circuit and tools;
- to be able to use basic equations in Theoretical Mechanics and Mechanics of continue; to solve theoretical tasks in Mechanics and Fluid mechanics while conducting research, technological and industrial affairs;
- to be competent in laws and notions which determine the cooperation of optical emission, laws of wave optics and geometrical optics, methodology of research tests of optical systems;
- to bear basic views about electromagnetic behavior of materials, to know the methods of electrodynamics and theoretical description of electric current;
- to be able to describe wave-particle dualism in atoms, to able to link the structure of atom and molecular systems and their physical and chemical characteristics;
- to know about the fundamentals of the radioactive decay and kernel regression, to be able to solve the tasks of radioactive decay of cores, to make calculations for Q-factor of nuclear reactions, energy of nuclear links;

Co-funded by the Erasmus+ Programme of the European Union

- to be competent in the laws of thermodynamics and statistical Physics, to determine the laws of thermodynamics applying to the methods of statistical mechanics and to solve important tasks in thermodynamics and statistical physics;
- to be competent in the laws and basic methods of theoretical descriptions of quantum-mechanical systems;
- to be competent in the basic methods of staff and people protection from negative effects of anthropogenic, anthropogenous, technogeneous origin, competence in the fundamentals of rational use of natural resources, legal, managerial, technical fundamentals of safe labour.

4.5.2 Learning outcomes: 1-02 05 02 "Physics and Informatics"

Learning outcomes are measured and evaluated by the quality of competences achieved by the students who have completed the program 1-02 05 02 "Physics and Informatics" in full. The competences are divided into 3 groups: academic competencies, social-personal competencies, professional competencies.

Academic competencies involve knowledge and skills for studies of academic disciplines and develop skills for investigating. Social-personal competencies involve cultural-valuable orientations, knowledge of ideological and moral values of modern society and state and skills to follow them. Professional competencies involve the skills to solve tasks, to develop plans and to implement the plan in accordance with professional activities.

A student who has completed the full program must obtain the following academic competences:

- to have basic skills for research and theory knowledge for solution of theoretical and practical tasks;
- to know methodology for scientific and pedagogical research;
- to develop skills for research activities;
- to work independently;
- to be capable for creation of new ideas (be creative);
- to use interdisciplinary approach when the tasks are solved;
- to have skills to use technical devices, to process the information and use the computer;
- to have skills for oral and written communication;
- to be able for studies, to upgrade the qualification longlife;
- to be able to regulate cooperation in the educational process.

A student who has completed the full program must obtain the following social-personal competences:

- to have civic consciousness;
- to be capable for social cooperation;
- to have skills for interpersonal communication;
- to have skills for health protection;
- to be able to criticize and been criticized;
- to have a team spirit;
- to be capable for self-education and self-imperfection in profession.

A student who has completed the full program must obtain the following professional competences:

- to manage cognitive and study-research activities for the students;
- to use optimized methods, forms and means of studies;
- to arrange and hold lessons of various forms and types;
- to arrange individual work of students;
- to use optimized selection and implement education in an effective way;

Co-funded by the Erasmus+ Programme of the European Union

- to arrange and hold educational events;
- to form basic components of personal culture of a student;
- to implement form teacher's activities in an effective way;
- to hold preventive measures from deviant behavior of students;
- to develop skills for individual work of students when work with academic, reference, research literature;
- to develop academic abilities and skills of students on the basis of systematized pedagogical diagnostics;
- to arrange and hold correctional and pedagogical activities with students;
- to caution and overcome academic failures of students;
- to form educational and training aims;
- to evaluate academic achievements of students as well as the level of their educatedness;
- to implement professional self-education and self-upbringing with the aim to enhance professional activities;
- to arrange a complete pedagogical process with regard to modern educational technologies and innovations in Pedagogics;
- to analyze and evaluate pedagogical phenomena and events which happened in the past and treat them through the lens of humanitarian knowledge.

4.6. Duration of the program

4.6.1 Duration of the program: 1-31 04 08 "Computerized Physics"

The duration of the study program 1-31 04 08 "Computerized Physics" is 4 years.

4.6.2 Duration of the program: 1-02 05 02 "Physics and Informatics"

The duration of the study program 1-02 05 02 "Physics and Informatics" is 4 years (full-time studies).

4.7. Study courses and ECTS distribution

4.7.1 Study courses and ECTS distribution: 1-31 04 08 "Computerized Physics"

No.	STUDY COURSES	ECTS
1	**State component**	**139**
1.1	**Social and humanitarian module -1**	
1.1.1	History	2
1.1.2	Economics	4
1.1.3	Philosophy	4
1.1.4	Political Sciences	2
1.2	**Module "Foreign language"**	
1.2.1	Foreign language	9
1.3	**Module "Mechanics"**	
1.3.1	Mechanics	9
1.4	**Module "Advanced Mathematics – 1"**	
1.4.1	Mathematical analysis	6
1.4.2	Analytical Geometry and Linear Algebra	6
1.4.3	Fundamentals of vector and tensor analysis	3

Co-funded by the Erasmus+ Programme of the European Union

1.5	**Module "Software development"**	
1.5.1	Software development	6
1.5.2	Hardware-and-software interface of the informational systems	3
1.5.3	Introduction into interpreted languages	3
1.6	**Module "Advanced Mathematics – 2"**	
1.6.1	Complex variable theory	6
1.6.2	Differential equations	6
1.6.3	Theory of Probability and Mathematical Statistics	3
1.6.4	Equations of Mathematical Physics	6
1.6.5	Fundamentals of Mathematical Modelling	3
1.7	**Module "Molecular Physics"**	
1.7.1	Molecular Physics	8
1.8	**Module "Electricity and Magnetism"**	
1.8.1	Electricity and Magnetism	9
1.9	**Module "Theoretical mechanics"**	
1.9.1	Theoretical mechanics	6
1.10	**Module "Optics"**	
1.10.1	Optics	8
1.11	**Module "Electrodynamics"**	
1.11.1	Electrodynamics	6
1.12	**Module "Atom Physics and Nuclear Physics"**	
1.12.1	Atom Physics and Physics of atomic phenomena	8
1.12.2	Nuclear Physics	4
1.13	**Module "Thermodynamics, Statistical Physics and Quantum Mechanics"**	
1.13.1	Thermodynamics and Statistical Physics	6
1.13.2	Fundamentals of Quantum mechanics	3
2	**Component of the Educational Establishment**	
2.1	**Social and humanitarian module -1**	
2.1.1	*Optional subjects (1 out of 2)*	
2.1.1.1	Economics and management of innovations	2
2.1.1.2	Fundamentals of intellectual property management	
2.1.2	*Optional subjects (1 out of 2)*	
2.1.2.1	History of astronomic ideas	2
2.1.2.2	History of Physics	
2.2	**Module "Numerical techniques in Physics"**	
2.2.1	Numerical techniques in Physics	6
2.3	**Module "Integrated systems for data processing and modelling"**	
2.3.1	Modern integrated packages for analysis and modelling of processes and systems	3
2.3.2	Management of database systems	3
2.4	**Module "Electronics and Quantum Electrodynamics"**	
2.4.1	Introduction into Electrical technology and Electronics	3
2.4.2	*Optional subjects (1 out of 2)*	
2.4.2.1	Introduction into Solid-state electronics	3
2.4.2.2	Quantum electronics and Holography	

Co-funded by the Erasmus+ Programme of the European Union

2.5	**Module "Technical and software supply for the experiment"**	
2.5.1	*Optional subjects (2 out of 4)*	
2.5.1.1	Computer architecture	3
2.5.1.2	Experimental Physics	
2.5.2.3	Application development on Java platform	3
2.5.2.4	OS level software	
2.6	**Module "Course work"**	
2.6.1	Course work "Object-oriented programming"	1
2.6.2	Course work "Computational experiment in Physics"/ "Computer modelling of Physical systems, processes, phenomena"	2
2.7	**Courses of the specialization 1-31 04 08 03 "Computer modelling of physical processes"**	**39**
2.7.1	**Module "Software programming languages"**	
2.7.1.1	Object-oriented programming	3
2.7.1.2	Special Laboratory Practicum "Object-oriented programming"	3
2.7.2	**Module "Computational Physics – 1"**	
2.7.2.1	Computational experiment in Physics	
2.7.2.2	Special Laboratory Practicum "Computational experiment in Physics"	3
2.7.3	**Module "Computational Physics – 2"**	
2.7.3.1	Computer modelling of physical processes and phenomena	3
2.7.3.2	Special Laboratory Practicum "Computer modelling of physical systems, processes and phenomena"	3
2.7.4	Module "Modern informational technologies"	
2.7.4.1	Parallel programming	6
2.7.4.2	Operational systems and system programming	6
2.7.4.3	Fundamentals of application development	3
2.7.4.4	Computer graphics and engineering graphics	6
2.7.4.5	Special Laboratory Practicum "Modern technologies of software development"	3
3	**Elective courses**	
3.1	Research problems in Physics	2
3.2	Fundamentals of informational technologies	
3.3	Foreign language	
3.4	Physical education	
3.5	Physics of real crystals	
3.6	Fundamentals of optoelectronics	
4	**Additional types of studies**	
4.1	Physical education	
4.2	Belarusian (functional lexis)	
4.3	Vital activity security	

4.7.2 Study courses and ECTS distribution: 1-02 05 02 "Physics and Informatics"

No.	STUDY COURSES	ECTS
1	**Social and humanitarian cycle of disciplines**	**17**

Co-funded by the Erasmus+ Programme of the European Union

	State component	**13**
1.1	Integrated module "History"	3
1.2	Philosophy	3
1.3	Integrated module "Economics"	4
1.4	Integrated module "Political Sciences"	3
	Higher educational establishment component	
	Pedagogical ethics and aesthetics/ History of world culture	2
	Fundamentals of law and human rights/ Personal sociology	2
2	**General scientific and general professional cycle of disciplines**	**49**
	State component	**33,5**
2.1	Pedagogics	11
2.2	Psychology	7
2.3	IT in Education	3
2.4	Foreign language	7,5
2.5	Vital activity security	3
2.6	Belarusian (functional lexis)	
	Higher educational establishment component	**15,5**
2.7	Introduction into profession of a teacher	1,5
2.8	Theory and practice of special education	2
2.9	Methodology of work at summer recreation camps for children	2
2.10	Development physiology and hygiene at school	2
2.11	Form teacher working technologies	2
2.12	Fundamentals of intellectual property management	2
2.13	Astronomy	4
2.14	Holography in photorefractive crystals	
3	**Cycle of special disciplines**	**147**
	State component	**88**
3.1	Mathematical analysis	14
3.2	General Physics	36
3.3	Physics teaching methodology	7
3.4	Methodology and technology of experiments in Physics	2
3.5	Modern means for teaching Physics	2
3.6	Computer graphics and Multimedia	4
3.7	Technologies of software development and methods of algorithmization	9
3.8	Information systems and nets	7
3.9	Informatics teaching methodology	5
3.10	Course project	1
3.11	Course project	1
	Higher educational establishment component	**59**
3.12	Introduction into Advanced Mathematics	3
3.13	Algebra and Geometry	10
3.14	Theoretical Physics (included the chapter «Electrodynamics»)	10,5
3.15	Processing methods of research results	2
3.16	Integrated course of Physics for school	3
3.17	Methodology of Mathematical Physics	3

Co-funded by the Erasmus+ Programme of the European Union

3.18	Fundamentals of Acoustooptics/ Physics of real crystals	2
3.19	Teaching of methodology for solution of tasks in Physics	4
3.20	Introduction into Quantum electronics	2
3.21	Physical electronics	7
3.22	Architecture and software of informational systems	3
3.23	Computer modelling of physical processes and phenomena	5
3.24	Practical training on solution of tasks in Informatics	2,5
3.25	Research problems in Physics	2
4	**Additional types of training**	
	Physical education	

4.8. Final assessment

Final assessment is implemented by the State Examination Board. The students who have completed the academic plan and the academic program, are allowed to pass the final assessment. There are 2 forms of the final assessment developed for Study program 1-31 04 08 "Computerized Physics" and 1-02 05 02 "Physics and Informatics": State examinations (in the key course(s) with regard to the speciality; in the course (s) with regard to specialization) and Graduation paper presentation. While getting ready for the examination the students form and develop the competencies mentioned in the list above. State examination is held at the session of the State examination board. The program of the State examinatio is developed by the University in accordance with the Rules for final assessment of students.

Graduation paper of a student must meet the requirements developed by the University but it must correlate with the Standards of Education and the Rules for Final Assessment of students. The topic of the graduation work must be of current interest and bear practical significance.

Final assessment of the academic level of the students is measured by the State examination board, in its turn the final assessment of the project is evaluated by the EU commission. In view of this the administration of MSPU named after I.P.Shamyakin decided to introduce several substitutions into the curriculum development project. The justification of these substitutions are mentioned below.

1. Substitution of the academic discipline "Quantum electronics and holography" with academic discipline "Electrodynamics".

Substitution of academic discipline "Quantum electronics and holography" with academic discipline "Electrodynamics" is determined by the reason mentioned below.

Academic discipline "Electrodynamics" is included into the State component of the speciality "Computer Physics. Computer modelling of physical processes". This discipline is also a part of the course "Theoretical Physics" included in the speciality "Physics and Informatics".

The aim of this academic discipline is to give knowledge about the basics of classical Electrodynamics, because this science which is based on the fundamentals of nature, where the facts about electricity and magnetism are generalized. The connection between electromagnetic phenomena and figures expressed in a mathematical form is shown. It is important to mention that there is a unity between electric and magnetic phenomena determined by physical entity and mathematical treatment and it determines the use of various methods of Mathematical Physics. Much attention is paid to the analysis of the laws of electromagnetics, Maxwell's equations, energy conservation, difference between macroscopic and microscopic approaches to the description of electromagnetic field, physical interpretation

Co-funded by the Erasmus+ Programme of the European Union

of consequences on the basis of Lorentz transformations, a relativistic formula of electrodynamics. Special theory of relativity is an integral part of Electrodynamics and it shows covariance of the laws of nature in relation to Lorentz group transformations.

2. Substitution in the title of the academic discipline "Research tasks in Physics".

After a thorough analysis over the new titles of the disciplines included into the 2 bachelor degree programs "Computerized Physics" and "Physics and Informatics" the administration of Physics and Engineering Department came to the conclusion that the discipline "Research tasks in Physics" would not correlate fully with the multiple problematic field of the studies it covered. The change of the title will lead to upgrade of the content and better quality of teaching.

3. Substitution in the title of the academic discipline "Computer modelling of physical systems, processes and phenomena".

In accordance with the educational standard OCBO 1-31 04 08-2013 and the academic plan of the discipline 1-31 04 08 03 "Computerized Physics. Computer modelling of the physical processes" No. 354 approved on 26.12.2018, the academic discipline "Computer modelling of physical systems, processes and phenomena" influences on the development of the following competencies: "A specialist must be capable for development of a physical-mathematical model of the investigated phenomena". In this regards it was offered to substitute the title of the academic discipline "Computer modelling of physical systems, processes and phenomena" with the title "Computer modelling of physical processes and phenomena", because it is treated as a more precise one. This discipline is studies in Semester 6, it includes 108 academic hours. 60 academic hours out of these 108 academic hours are classroom-based. It corresponds to 3 ECTS.

Thus, the substitutions mentioned above will lead to the improvement of the teaching process and upgrade of the students' competencies while studying and as a result it will influence directly on the quality of the project "Development of practically-oriented student-centred education in the field of modelling of Cyber-Physical Systems / CybPhys".

4.9. Analysis of the program for the relevance to the EQF level descriptors

(***https://ec.europa.eu/ploteus/en/content/descriptors-page***)

Analyzing a set of descriptions indicating the learning outcomes relevant to the qualifications at the levels in the European Qualifications Framework the graduates in 1-31 04 08 "Computerized Physics" and 1-02 05 02 "Physics and Informatics" are expected to

	Knowledge	**Skills**	**Responsibility and Autonomy**
Level 6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups

Co-funded by the Erasmus+ Programme of the European Union

5. Chernihiv National Technological University (CNTU)

5.1. SWOT analysis of the institution

Strengths

- Chernihiv National Technological University (CNTU) is the chief center of technical education and research in the north of Ukraine;
- CNTU is joined the Magna Charta Universitatum in 2013. CNTU is included in the list of priority higher educational establishments declared by Canadian Association of Engineers;
- CNTU's system of the quality management has been certified at the according to the international standard ISO 9001:2009 (ISO 9001:2008);
- CNTU's Cyber Physical Systems direction is represented by five profile departments in Computer Science, Electronic, Automation, Physics and Cyber Security fields where about 1000 students are studing of electronic and computer engineering under supervision of 10 professors and more then 20 PhD teachers;
- CNTU has a sucsses expearence in international activity as a performer of 4 projects on Tempus IV program in the Industrial and Computer Engineering fields;
- CNTU has scientific collaboration with National Academy of Science (Institute of Electric Welding named after E.O. Paton, Institute of Mathematical Machine and Systems Problems);
- CNTU's coordinator has got two State Prizes of Ukraine as in the field of Science and Technics and in the field of High Education related to automation control and computer system developments;
- CNTU has a wide interaction with industry enterprises and IT-cluster as a provider of high qualificated specialists;
- CNTU is a performer of more then 20 R&D projects including control systems of electron-beam welding machines, 3 automation lines and electronics systems;

CNTU has numerous labs with equipment from CISCO, NXP, Microsoft, Xilinx companies.

Weaknesses

- Lack of new practices in teaching for computer and electronics fields;
- Lack of licensed profile software for labs;
- Lack of methodic toolkits for training;
- Training is focused more on general competencies and misses the actual needs of engineering practice;
- Poor mobility of students and teachers;
- There is no proper focus on the market needs for engineering specialties;
- Theoretical gaps in the training of masters for R&D;
- Weak inventive and startup activities;
- Weak English speaking skills and limited international scientific communication;

insufficient efficiency of taking advantage of the Bologna system.

Co-funded by the Erasmus+ Programme of the European Union

Opportunities

- to focus the training in the relevant direction for Ukraine such as Cyber-Physical Systems;
- to expand the range of specialties at the master's level for Industry 4.0;
- strengthen R&D direction through the influx of highly qualified personnel and new innovative research directions;
- to establish a new master's level educational program "Computer engineering and Industrial Automation";
- to deepen the training in computer engineering by developing five new courses related to Cyber-Physical systems modelling;
- to improve the laboratory base by opening a new lab with licensed software for simulation of Cyber-Physical Systems;
- to increase the level of basic training on bachelor's level in the field of physical process modeling:
- to improve the English language skills of teachers and students and to create the conditions for their mobility and possibility an education of foreign students;
- to draw on the experience of colleagues from European universities in the preparation of highly professional specialists;
- to strengthen the influence of the Bologna principles

Threats

- competition between universities within Ukraine for ownership of master's degree programs in Industrial 4.0 area;
- ambiguity of the new accreditation system implemented in Ukraine since 2020;
- decrease in the level of state provision of universities
- lack of standards for masters' programs in the field of Cyber-Physical Systems;
- slow improvement of the investment climate in Ukraine, which influences the needs of the highly skilled specialist on the labor market;
- costly resources and unstable financial situation in Ukraine;
- the domination of outsourcing over R&D in Ukraine.

5.2. Type of study program

Higher Education Degree: Master's degree (MSc)

Knowledge Area: 12 Information technologies

Specialty: 123 Computer Engineering

Restrictions on forms of study: Full-time and correspondence forms of study

Educational Qualification: Master in Computer Engineering and Industrial Automation

Professional Qualification: 2139.2 - Computer engineer

Diploma qualification: Master of Computer Engineering and Industrial Automation

The subjects of **professional activities of the graduate** are Computer Engineering and Industrial Automation.

5.3. Aims and objectives

Co-funded by the Erasmus+ Programme of the European Union

The aim of study program is training of qualified, competitive masters for Research and Development in the field of Computer Engineering, Industrial Automation and Intelligent Manufacturing Systems. The program is a multi-disciplinary subject, with applications across a wide range of industrial sectors. The program is geared for graduates from a variety of scientific and engineering disciplines.

The main Program Education Objectives are

- to prepare competent graduates having strong knowledge, updated with modern technology to provide the effective solutions for engineering problems in computer engineering for Industrial 4.0;
- to provide an advanced education in control and systems engineering, emphasising modern theoretical developments and their practical application;
- to give a sound fundamental understanding of the principles underlying the application of control systems'
- to enable students to apply modern control principles in various areas of industry;
- to prepare the graduates to work with strong professional skills, sense of responsibilities, understanding of legal and safety, cyber security and environmental issues.
- to prepare motivated graduates with research attitude, lifelong learning, investigative approach, and multidisciplinary thinking.
- to prepare the graduates with strong managerial and communication skills to work effectively as individual as well as in teams.

5.4. Summary

The program is to give students the opportunity to develop essential skills for both academic and industrial applications. Participants will gain a wide advanced knowledge in modern computer technjlogies in the design and application of computer nets and systems, computerized automation, programming and control Intelligent Manufacturing Systems. They also will establish a deeper understanding of the computer modelling of the Cyber-Physical Systems and their own skills in it. Graduates of the program will have opportunities in careers based on their specialization in Industrial 4.0. But the strong and varied knowledge base they develop throughout of training can make them attractive to a wide range of employers. Graduates will have the experience for an advantage in the job market - they will abbility to bring a own contribution into the growing of a company. By joining the programme students will become a members of the Industrial Masters' community. The master's program also serves as an excellent foundation for students who wish to continue into a PhD program.

5.5. Learning outcomes

Cognitive learnung outcomes:

- to find an original innovative solution aimed at solving a specific problem of computer engineering;
- to apply knowledge of computer science and engineering skills to solve of complex problems on creation of modern automation systems for Industry 4.0;
- to find solutions of complex problems by conducting investigations applying system analysis, mathemetical models, simulation of physical processes
- to organize and conduct research related to computer systems and networks;
- to model and to simulate processes and objects using software;

Co-funded by the Erasmus+ Programme of the European Union

- to study processes occurring in computer systems, networks and their components based on mathematical models;
- to process the obtained results, analyze and comprehend them, present the results of work at the modern scientific, technical and professional level;
- to analyze, evaluate and select the hardware and software components of computer systems and networks;
- ability to master and develop documentation for information technology systems, products and services,
- to support teamwork, planning and effective organization of work, continuous quality control of work results;
- to apply basic knowledge of standards in the field of information technology in the development and implementation of information systems and technologies;
- to use administrative, legal, economic and educational levers to influence natural resource users;
- to search information in different sources for solving specialty tasks;
- to adapt the usage of modern tools and recent software
- to contribute towards the society by understanding the impact of computerization and automation on global aspect
- to understand environment issues and design a sustainable system
- to demonstrate effective communication at professional area.

Practical learnung outcomes:

- ability to construct effective algorithms for formal prediction, models and methods for meaningful prediction in science and technology by using the principles of operation and structure of technical means, mathematical models,
- ability to develop and research models of objects and processes;
- ability to support the author's design processes, implementation of information systems and technologies;
- ability to analyze, optimize and model the architectures of computer systems and networks using modern principles of mathematical, software, linguistic, technical and information engineering;
- ability to plan experimental and theoretical research, to choose algorithms for processing digital signals;
- ability to develop design strategies, define design goals, performance criteria, applicability limitations, ability to develop new methods and tools for designing computer systems and networks;
- ability an understanding of the foundations of various forms of (semi-/un-) structured data and their formalisms.
- ability an understanding of the data models, their relevant properties, and be able to analyse their use in a given digital manufacturing.
- ability to discuss trade-offs between various formalisms, and between different data models

5.6. Duration of the program

Program duration is:

- on a professional level 1.5 years

Co-funded by the Erasmus+ Programme of the European Union

5.7. Study courses and ECTS distribution

Code	Title of course	ECTS
General disciplines		
GC 1	English (Professional Communication)	4
GC 2	Civil protection and labor protection in the industry	3
GC 3	Intellectual Property	3
GC 4	Technologies of Software systems design	6
GC 5	Design of computer systems and networks	5
GC 6	Design of Embedded Computer Systems	**5**
GC 7	**Programming of Automation Systems**	**5**
GC 8	**Modelling and Measurement of physical processes in Robotics**	**5**
Optional disciplines		
OC 1.1	Modern data processing methods and technologies	5
OC 1.2	**Simulation of Manufacturing Environment**	**5**
OC 2.1	Multiplatform environments and virtualization	5
OC 2.2	**Model-oriented control in Digital Manufacturing**	**5**
OC 3.1	Intellectual robots	5
OC 3.2	Modern cybersecurity methods and technologies	5
OC 4.1	**Design and Simulation of Power electronics components**	**5**
OC 4.2	Software for specialized computer systems	5
OC 5.1	Distributed computing and cloud technologies	4
OC 5.2	Real-time operating systems	4
	Practical training	
PT 1	Pre-diploma practice	12
	Certification	
MT 1	Master's thesis	18
TOTAL		**90**

5.8. Final assessment

The graduate certification of the educational program "Computer Engineering and Industrial Automation" of specialty 123 " Computer Engineering " is carried out in the form of the defence of master's thesis and ends with the issuance of the document of the established sample on the award of the master's degree with the qualification of master's degree in Computer Engineering and Industrial Automation. The defence of master's thesis shall be open and public with a preliminary check for plagiarism.

5.9. Analysis of the programe for the relevance to the EQF level descriptors

Higher Education Level: FQ-EHEA - Second Cycle, EQF LLL - Level 7, NQF - Level 7 / Master.
Graduate Academic Rights: FQ-EHEA Third Cycle Opportunity, EQF-LLL Level 8, and NQF Level 8.

Co-funded by the
Erasmus+ Programme
of the European Union

(***https://ec.europa.eu/ploteus/en/content/descriptors-page***)

Co-funded by the Erasmus+ Programme of the European Union

6. Kharkiv National Automobile and Highway University (KhNAHU)

6.1. SWOT analysis of the institution

KhNAHU, a state university founded in 1930, is one of the leading technical universities in Ukraine with the highest level of accreditation. It provides training of Bachelors in 20 fields of knowledge, Masters – in 18 fields. The amount of academic staff is 435 professors' and teachers' staff among them 336 staff with degrees and titles of honour, 60 Doctors of Science, 276 PhDs. The number of students is 4,622 including 554 international students. 6 faculties and 34 departments of KhNAHU offer higher education programmes in engineering and automobile transport. The university has 25 international bilateral contracts with universities and enterprises of the USA, China, Latvia, Lithuania, Belarus, Bulgaria, Poland and Germany continuous participating in granted projects on training, traineeships, scientific research. It has the students' exchange programmes with Poland, Germany and other universities abroad. German-Ukraine Centre as a part of integration in German higher education and automobile industry has been created on a university base. To broad international projects participation and contacts KhNAHU actively takes part in project proposals held by international funds and institutions focused on modernization and quality improvement of training and expansion of educational mobility, development of joint programmes and international collaboration as well.

6.2. Type of study program (copy points 6.2-6.8 if you describe more than one program)

Higher Education Degree: Master's degree (MSc)
Knowledge Area: 14 Electrical Engineering
Specialty: 141 Electricity, electrical engineering and electromechanics
Restrictions on forms of study: Full-time and correspondence forms of study
Educational Qualification: Master in Electric Vehicles and Energy Saving Technologies
Professional Qualification: 2149.2 - Electromechanical engineer
Diploma qualification: Master of Electrical Vehicles and Energy Saving Technologies
The subjects of **professional activities of the graduate** are electric systems and complexes of vehicles, energy efficient technologies in transport and in the transport infrastructure.

6.3. Aims and objectives

Training of qualified, competitive specialists for research and project-technological work in the field of electrical systems and vehicles complexes; for design and development activities aimed at meeting the requirements for the development of energy efficient electrical systems and vehicle complexes; for organizational-managerial activity, implementation of interdisciplinary projects in the professional field, teamwork, self-study and continuous professional self-improvement.

Co-funded by the Erasmus+ Programme of the European Union

6.4. Summary

Educational training program for specialists of the second (master's) level of higher education in specialty 141 «Electricity, electrical engineering and electromechanics» developed in accordance with the Law of Ukraine «On Higher Education» adopted on July 01, 2014 № 1556-VII, Resolution of the Cabinet of Ministers of Ukraine adopted on November 23, 2011 «On Approval of the National Qualifications Framework» adopted on December 30, 2015 No. 1187, «On Approval of Licensing Conditions for Implementing Educational Activities of Educational Establishments» adopted on December 20, 2015 Methodological Recommendations «Development of Educational Programs. Guidelines» (2014).

The educational program determines the prerequisites for access to training, the orientation and main focus of the program, the amount of ECTS credits required to obtain a master's degree, a list of general and special (professional) competences, the normative and variant content of specialist training, formed in terms of training results and requirements for the quality control of higher education.

6.5. Learning outcomes

Program Learning Outcomes (LO):

LO1. To master a methodology of scientific and technical knowledge taking into account the features of sustainable development in the system "man machine-environment". To apply logical analysis in solving professional issues and substantiate their own worldview and social positioning.

LO2. To demonstrate proficiency in English, including specialized terminology in order to work with technical documentation and perform literature search.

LO3. To possess the principles, methods and forms of organizing the pedagogical process and academical activities, the abilities to apply pedagogical and psychological techniques in professional and management activities.

LO4. To acquire the mechanisms of protection of intellectual property rights, to create favorable conditions for the introduction of intellectual property rights into production, to use regulatory documents on the quality, standardization and certification of electric power and electrotechnical objects.

LO5. To know the procedure of estimate cost when selecting the element base and stages of electronic devices synthesis, to calculate the cost price of manufacturing products, to be able to calculate the cost-effectiveness of new implementations, to determine reserves for its improvement, to keep records of the main activities of a company and to be able to calculate its efficiency.

LO6. To know the methods and technology of making sound management decisions, organizing comprehensive material support and organizing the control over its implementation.

LO7. To know the methods of measuring and controlling the content of harmful substances during the operation of motor vehicles, the impact of harmful substances on human health and the environment.

Co-funded by the Erasmus+ Programme of the European Union

LO8. To know the procedure of creating the protection for the population in emergency situations and to have a method of forecasting the possible radiation, chemical, biological situations, which can result from a natural disaster or an accident.
LO9. To manage the preparation and carrying out of rescue works on the objects of economic activities in accordance with the occupied position and specialty.
LO10. To perform the functions, duties and responsibilities of the occupational health and safety on the workplace, in the work enviroment, to avoid occupational and electric injuries, occupational diseases and take proper preventive measures.
LO11. To acquire the basics of planning and conducting various methods of physical researches; to know the equipment, methods and techniques of an experiment; to be able to evaluate the results obtained, their accuracy and the choice of a more reliable method.
LO12. To know the methods of developing intelligent management information systems, to make a competent choice for solving design issues between microcontrollers with rigid logic, FPGA, fuzzy logic or neural networks.
LO13. Ability to apply modern information technologies, to manage information using various applications, to use network computer technologies, databases and packages of applications in their professional field.
LO14. To know the mathematical methods of analysing and describing processes, analytical researches of mathematical object models, the principles of formal description of real processes.
LO15. To use mathematical skills in analysis when modeling the effects of electrical control systems on a research object.
LO16. To know the methods, techniques and principles for developing electrical systems for cars, electric and hybrid motor vehicles.
LO17. To be able to model and synthesize electric power and traction systems of environmentally friendly motor vehicles.
LO18. To acquire technical and normative basis, modern norms and standards of developing electrical systems of environmentally friendly motor vehicles.
LO19. To acquire the methods of structural synthesis of electrical control systems and vehicles complexes, to calculate electric circuits and to select elements according to the calculated parameters.
LO20. To know the basics of developing microcontroller systems and the methods of programming them.
LO21. To carry out the research of existing electrical systems operation to detect any malfunctions and to acquire the methods for preventing and eliminating them.
LO22. To be able to set the goal of the research and to formulate the tasks for its practical achievement, to analyze the results obtained.
LO23. To know the basic principles of developming research works for improving existing electrical systems of motor vehicles and developing, managing new ones.

Professional learning outcomes

Co-funded by the Erasmus+ Programme of the European Union

Technological abilities:

Ability to develop technical tasks for designing technological processes in the production of electrical systems and vehicles complexes.

Ability to design technological processes in the production of electrical systems using automated systems for the technological production preparation.

Ability to develop technological documentation for electrical systems and vehicle complexes.

Ability to ensure the manufacturability of electrical systems and vehicles complexes and their manufacturing processes, to evaluate the economic efficiency of technological processes.

Ability to carry out the authorial support of the developed systems at the stages of design and production.

Designing abilities:

Ability to analyze the state of scientific and technical issues by selecting, studying and analyzing literature and patent sources.

Ability to define goals, carry out the tasks of designing electrical devices, systems, networks, circuits and devices with various functional purposes, to prepare technical tasks for the execution of design works.

Ability to design electrical systems and vehicles complexes with the given requirements.

Ability to develop design and engineering documentation in accordance with the methodological and regulatory requirements.

Research abilities:

Ability to define the goals and objectives of scientific research in accordance with the trends and prospects of the development of electric power, electrical engineering and electromechanics.

Ability to reasonably choose theoretical and experimental methods and means of solving defined tasks.

Ability to develop effective algorithms for solving defined tasks using modern programming languages and to provide them with the software implementation.

Ability to master planning principles and methods of experiment automation on the basis of information and measuring complexes, as a means of improving the accuracy and reducing the cost of conducting it, to master the skills of measuring in real time.

Ability to make scientifically sound conclusions based on the theoretical and experimental researches, to make recommendations for the improvement of devices and systems, to prepare scientific publications and to file applications for inventions and useful models.

Organizational and management abilities:

Ability to provide operative management and control of the unit staff operation, to participate in its motivation and stimulation for the purpose of further and advanced training and also retraining.

Ability to practically ensure the high-quality implementation of technological processes by employees in compliance with safety rules, fire protection and the requirements of environmental legislation.

Co-funded by the Erasmus+ Programme of the European Union

Ability to keep technical documentation (work schedules, instructions, budget estimate, plans, requests for materials and equipment), to systematize and summarize the information on the use and formation of enterprise resources).
Ability to control incoming, internal movement, disposal of fixed assets, to arrange maintenance, scheduled preventive repairs, to adjust equipment in accordance with the adopted plans and schedules and to monitor their implementation.
Willingness to participate in the support of a single information space for planning and managing an enterprise at all stages of the product life cycle.
Willingness to participate in the technical-economie study and functional-cost analysis of the market efficiency of a created product.

6.6. Duration of the program

1.5 years or 2 years

6.7. Study courses and ECTS distribution

№	Type of educational activity	ECTS
1	**Compulsory disciplines**	**63,5**
1.1.	**General training disciplines**	**16,0**
1.1.1.	**Disciplines of humanities and socio-economic training**	**10,0**
1	Philosophy of Science	4,0
2	Foreign Language	3,0
3	Intellectual Property	3,0
1.1.2.	**Disciplines of natural science (fundamental) training**	**6,0**
4	Civil protection and labor protection in the industry	3,0
5	Mathematical modeling and optimization methods	3,0
1.2.	**Disciplines of professional training**	**47,5**
6	Methods of planning scientific researches in motor vehicles	5,5
7	Computer control of ECTS	9,0
8	Scientific internship	3,0
9	Graduation diploma project	30,0
2.	**Optional disciplines**	**26,5**
2.1.	**General training disciplines**	**14,0**
2.1.1.	**Disciplines of humanities and socio-economic training**	**10,0**
10	Pedagogy and psychology of higher school Psychology of conflict	3,0
11	Practical marketing Enterprise Economy	3,0
12	Environmental aspects of car recycling Innovation Management	4,0
2.1.2.	**Disciplines of natural science (fundamental) training**	**4,0**
13	The theory of car operation Operation and maintenance of machines	4,0
2.2.	**Disciplines of professional training**	**12,5**
14	Intelligent information technologies and systems	8,5

Co-funded by the Erasmus+ Programme of the European Union

№	Type of educational activity	ECTS
	Energy-saving technologies in transport	
15	Electrical systems of environmently friendly motor vehicles	4,0
	Development of hybrid and electric vehicles	
	TOTAL according to the curriculum	**90,0**

6.8. Final assessment

The graduate certification of the educational program of specialty 141 "Electricity, electrical engineering and electromechanics" is carried out in the form of the defence of master's thesis and ends with the issuance of the document of the established sample on the award of the master's degree with the qualification of master's degree in electric vehicles and energy-saving technologies. The attestation shall be open and public.

6.9. Analysis of the programe for the relevance to the EQF level descriptors

Higher Education Level: FQ-EHEA - Second Cycle, EQF LLL - Level 7, NQF - Level 7 / Master
Graduate Academic Rights: FQ-EHEA Third Cycle Opportunity, EQF-LLL Level 8, and NQF Level 8

(*https://ec.europa.eu/ploteus/en/content/descriptors-page*)

Co-funded by the Erasmus+ Programme of the European Union

7. Kryvyi Rih National University (KNU)

7.1. SWOT analysis of the institution

Strengths:

The competitive advantages of the curricula are provided by the extensive scientific and educational experience of teachers in the field of process control and production. 15 of 19 teachers of the Department of Automation, Computer Science and Technology are represented in the SCOPUS database. Total Index Worse than faculty members – 59 points.

The curricula are provided by the developed material and technical base of the department (Schneider Electric, Festo, Siemens, Mitsubishi Electric, Arduino, etc.) and close cooperation with industry representatives and their participation in the development of the program, a stable base of practices and the implementation of joint research and production projects in particular international level.

The close links between KNU and employers helps to reduce the gap between the university and industries and provides the necessary conditions for the creation of new forms and methods of cooperation with employers.

The University is constantly working to improve the material and technical base, develop various forms of international cooperation, widespread use of electronic textbooks, manuals, corporate information and computer networks in the educational process, and integration into the global educational space.

Weaknesses:

The current method of financing, which negatively affects the long-term development planning and achievement of the main goals, is one of the most serious shortcomings.

Too few strategic partnerships with international scientific institutions are manifested by the inability to fully comply with foreign counterparts of educational programs and curricula, teaching methods, simplification of mobility mechanisms and recognition of qualifications.

The lack of practice in teaching disciplines in English does not allow to expand opportunities for intensifying the recruitment of foreign students and academic mobility.

7.2. THE STUDY PROGRAM TRANSPORTATION TECHNOLOGIES (ROAD TRANSPORT)

7.2.1. TYPE OF STUDY PROGRAM

Degree of higher education	1-st Bachelor`s Program (NQF)
Subject Area	27- Transport
Specialty	275 – Transportation technologies (Road transport)
Qualification	Bachelor in transportation technologies
Subject area description	*The subject is* the transport systems and technologies. *The aim of the study is* the training of specialists, which can

Co-funded by the Erasmus+ Programme of the European Union

	solve complex and specific problems in the field of transport utilizing scientific approach and in the light of comprehensiveness and uncertainty of transport system operation. *The theoretical content of the subject area is* terms, methods, principles of system analysis, transportation processes and systems, optimal decisions that determine relationships of design, development and operation of transport system and technologies. *The procedures are* –qualitative tools of system analysis; –operational performance analysis, mathematic and simulation modelling, graph theory methods, statistical analysis; –techniques of construction of algorithm of transportation processes; –technologies of passenger and cargo handling at the different transport types; – technologies of transport types using in the branches of economic activity. *The tools and equipment are* industry devices and information systems.

7.2.2 AIMS AND OBJECTIVES

The aim of the educational activity of Kryvyi Rih National University (hereinafter - the University) in the specialty 275 "Transportation Technologies (road transport)" at the first (Bachelor) higher education is the professional training of specialists capable of solving complex tasks in the field of road transport and transportation.

The objectives of professional activity of graduates are:

– comprehensive arrangement of transportation by public transport and specialized motor transport to ensure productive and accident-free operation of vehicles;

– organization and implementation of control over the operation of the transport process, optimization of the components of handling operations and carting, the use of industry regulatory documents and production management enhancement;

– technique of data handling for design of technological processes of freight transport by road, analysis of parameters and processes that provide the specified performance of road transport in the line of duty.

7.2.3 LEARNING OUTCOMES

Learning outcomes are statements that describe significant and essential learning that learners have achieved and can demonstrate at the end of a course or program. The core learning outcomes from the study program "Transportation technologies (Road transport)" of the first (bachelor) higher education are:

1) integral competence

Co-funded by the Erasmus+ Programme of the European Union

ability to solve complex and specific problems during professional activity in the motor transport industry or training, which involves the practical application of theory and technique of transportation structuring;

2) universal competences

- ability to analyze, categorize, compare, differentiate

–ability to synthesis namely design, formulate, organize

–ability to put knowledge to use

–ability to communicate in the state language both verbally and in writing

–ability to communicate in a foreign language

–interpersonal skills

–ability to identify, ask and solve problems

– teamwork ability

– ability to exercise rights and responsibilities as a society member and to realize the values of a civil democratic society and the need for its sustainable development

– ability to preserve and multiply moral, cultural, scientific values and achievements of society based on an understanding of history and patterns of development of the subject area as well as its place in the general knowledge system, society and technology;

3) special (professional, subject) competencies:

– ability to apply the legal and regulatory framework, as well as national and international requirements, practices and standards for professional activity in the field of transport technologies;

– ability to use modern methods to ensure the high-quality operation of cars and special purpose vehicles, improve the arrangement of transportation as well as productive and accident-free operation of vehicles;

–ability to use professionally profiled knowledge and practical skills in the field of passenger and freight transportation in respect of motor transport efficiency improvement and fuel saving.

– ability to use professionally-profiled knowledge and skills in the operation and maintenance of machines and special purpose vehicles to improve the maintenance methods

– ability to use book knowledge and practical skills in the field of licensing and certification of transportation and mastering the basics of motor vehicle production management and business activity

– professionally profiled knowledge in the theoretical foundations of computer science and practical use of information technologies;

– computer skills at the user level, using modern information technology to solve experimental and practical tasks in the field of professional activity;

– ability to draw up the obtained results in the form of presentations, technical reports;

– ability to justify methods selection for special problems solving, to critically evaluate the obtained results, to justify and defend the decision-making.

7.2.4 DURATION OF THE PROGRAM

Co-funded by the Erasmus+ Programme of the European Union

The study program is of the first (bachelor) higher education level. The length of the program is 240 ECTS credits. There are

– theoretical education (213 ECTS credits) in courses in the form of classes (lectures, seminars, laboratories and practicals) and unsupervised activities;

– physical education (6 ECTS credits)

– 2 course papers in the educational disciplines (5 ECTS credits)

– educational practical training (2 weeks, 3 ECTS credits)

– the first industrial practical training (4 weeks, 6 ECTS credits)

– the second industrial practical training (4 weeks, 6 ECTS credits)

– state exam in Bachelor's defence (1 ECTS credit).

The duration of the program is 3 years and 10 months based on senior secondary education or 2 years and 10 months based on the degree of junior specialist.

7.2.5 STUDY COURSES AND ECTS DEISTRIBUTION

Table below shows the study courses and ECTS distribution

The name of the study course	ECTS	Hours
Physics	4	120
Engineering and Computer Graphics	4	120
Computers and Programming	6	180
Language for Business	6	180
Mathematics	14	420
History of Ukraine	4	120
Ukrainian (for specific purposes)	4	120
Theory of Probability and Mathematical Statistics	4	120
General Course of Transport	5	150
Philosophy	4	120
Technical Mechanics	4	120
Road Safety	4	120
Introduction to Speciality	4	120
Basic Theory of Transportation Processes and Systems	5	150
Modern Information Technologies on Transport	4	120
Systems Analysis Methods in Transportation Models	4	120
Operation Research in Transport Systems	4	120
Principles of System and Management Theories	6	180
Vehicles	6	180
Life Safety and Fundamentals of Lab our Safety	3	90
Logistics	6	180
Methods and Algorithms for Decision Making on Transport	6	180
Freight Transport by Road	7	210

Co-funded by the Erasmus+ Programme of the European Union

The name of the study course	ECTS	Hours
Fundamentals of Transport Economy	4	120
Basics of Marketing	4	120
Civil Passenger Traffic	9	270
Basics of Management	4	120
Transport Low	5	150
Systems and Technologies of Transport	4	120
Coordination of Transport Types	7	210
Automobiles	8	240
Open Pit Trucks	4	120
Automobile Operation and Maintenance	4	120
Technological Transport at Mining and Metallurgical Enterprises	4	120
Automated Control Systems on Transportation	5	150
Organization of Handling Operations	4	120
Automobile Transport of Deep Open Pits	4	120
International Operations	4	120
Technical Operation of Automobiles	4	120
Organization, Planning and Management of Automotive Production	5	150
Special-Purpose Vehicles	5	150
Navigation Equipment of Vehicles	4	120
Rules of Carriage, Licensing and Certification on Transport	5	150
Physical Training	6	180
Course Paper in Passenger Transportation	3	90
Course Paper in Vehicles	2	60
Course Project in Freight Traffic	3	90
Educational Practical Training	3	90
Industrial Practical Training	6	180
Industrial Practical Training	6	180
State Exam in Bachelor's Defence	1	30

7.2.6 FINAL ASSESSMENT

Assessment of student learning results is carried out due to the "Regulations on Educational Process Organization at Kryvyi Rih National University" and the "Regulations on the Procedure of Establishing and Organizing of the Work of the Examination Commission for Higher Education Applicants". The system of assessment of learning outcomes includes entrance, current, semester, deferred, rectorial and dean control of knowledge and competency test of higher education applicants. The final semester control is

Co-funded by the Erasmus+ Programme of the European Union

conducted in the form of an exam or differentiated credit that is defined by the curriculum in the terms stipulated by the schedule of the educational process and in the volume of course content regulated by its program (syllabus). The committee carries out defending course paper and projects at a time determined by the administrating sub-department, with the participation of the coursework or project supervisors.

Certification of graduates of the study program in specialty 275 "Transport technologies (road transport)" is validated in the form of defending of bachelor's graduate qualification work and ends with students awarding with the degree of "Bachelor of transport technologies (road transport)".

Requirements for the bachelor's graduation work defence are the examination committee consisting of representatives of employers and their associations provide that certification.

7.2.7 ANALYSIS OF THE PROGRAM FOR THE RELEVANCE TO THE EQF LEVEL DESCRIPTORS

Study program "Transportation technologies (Road transport)" relevance to European Qualification Framework descriptors

	Knowledge	**Skills**	**Responsibility and autonomy**
	In the context of EQF, knowledge is described as theoretical and/or factual.	**In the context of EQF, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments).**	**In the context of the EQF responsibility and autonomy is described as the ability of the learner to apply knowledge and skills autonomously and with responsibility**
Level 6 The learning outcomes relevant to Level 6 are	Systems analysis methods in transportation models. Decision-making approaches and algorithms on transport. Project management in the field of transport systems and technologies. Traffic flow theory. Knowledge about car-following models. Pedestrian behavior theory and modelling. Error theory concerning transportation.	To research transportation processes, test, analyze and evaluate transport system parameters. To formulate, modify, develop new ideas for transportation technologies efficiency improvement. To use modern information technologies for transportation real-world problems solving To develop, manage projects in the field of transport systems and transportation technologies. To develop, introduce safe working practices in the field of the transport system and transportation technologies. To develop and use transportation technologies considering environment conservation requirements. To research human-factor	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups

Co-funded by the Erasmus+ Programme of the European Union

	Knowledge	Skills	Responsibility and autonomy
	In the context of EQF, knowledge is described as theoretical and/or factual.	**In the context of EQF, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments).**	**In the context of the EQF responsibility and autonomy is described as the ability of the learner to apply knowledge and skills autonomously and with responsibility**
		problem relating to transport and consequences of errors for safety and control. To determine human behavior models due to errors.	

7.3. THE STUDY PROGRAM CYBER-PHYSICAL SYSTEMS

7.3.1. Summary

Field of knowledge - 15 Automation and instrumentation.
Specialty - 151 Automation and computer-integrated technologies.
Specialization - "Cyber-physical systems"

The objects of study and activities of masters in automation and computer-integrated technologies in the field of cyber-physical systems are: control objects (production processes, organizational structures), technical, informational, mathematical, software and organizational support of cyber-physical automation systems in various industries.

The theoretical content of the subject area includes the methodological apparatus for the synthesis, design and scientific research of objects and automation systems and cyber-physical systems based on the methods and principles of system analysis, the modern theory of automatic control, information theory, mathematical modeling and optimization, theory of algorithms, artificial intelligence.

The higher education applicant must master: modern methods and tools that are used for analysis, synthesis, design, commissioning, modernization and operation of cyber-physical automation systems and computer-integrated technologies; methodology of scientific research of control objects and automation systems of complex organizational and technical objects.

Orientation of the educational program: Educationally professional.

The emphasis of the program is on the formation of a specialist capable of solving complex scientific and technical problems in the field of cyber-physical systems of automation and instrumentation, development, design, commissioning and operation of automation systems, process control and computer-integrated production.

The main focus of the educational program

Co-funded by the Erasmus+ Programme of the European Union

Training specialists for organizational, managerial and engineering activities in the field of automation of cyber-physical systems and instrumentation with a focus on automation and computer-integrated technologies.

Keywords: cyber-physical systems, automation, computer-integrated technologies, technological measurements, controls, mathematical modeling, design, scientific research.

Features and differences

Integration of knowledge from promising areas of automation of cyber-physical systems and instrumentation, development, design, commissioning and operation of automation systems and computer-integrated production using specialized software. Training of highly qualified specialists at a high methodological and professional level.

7.3.2 Learning outcomes

Integral competence IC:

Ability to solve complex specialized tasks and practical problems, is characterized by the complexity and uncertainty of the conditions, in professional activities in the field of automation of cyber-physical systems and instrumentation, or in the learning process, involves the application of theories and methods of the industry.

General competencies:

GC1. Ability to conduct research at an appropriate level.

GC 2. Skills for implementing safe activities.

GC 3. Ability to communicate with representatives of other professional groups of different levels (with experts from other areas of knowledge / types of economic activity).

GC 4. Ability to generate new ideas (creativity).

GC 5. Ability to abstract thinking, analysis and synthesis.

GC 6. Ability to learn and master modern knowledge.

GC 7. Ability to search, process and analyze information from various sources.

GC 8. Ability to work in an international context

GC 9. Ability to formulate, pose and solve problems.

GC 10. Skills for using information and communication technologies

GC 11. Ability to develop projects and manage them.

Professional competencies

PC1. Ability to apply special knowledge to create effective automation cyber-physical systems for complex technological objects and complexes based on intelligent control methods and computer technologies using databases, knowledge bases and artificial intelligence methods.

PC 2. Special knowledge in the design and implementation of highly reliable automation systems and their application software, implementation of management and information processing functions based on modern provisions of the theory of reliability, functional safety of software and hardware, analysis and reduction of risks in complex systems.

PC 3. Ability to apply modeling and optimization methods to research and create effective control systems for complex technological and organizational and technical objects.

PC 4. Ability to use special software for the development of computer-integrated control systems and software and hardware systems based on industrial controllers, human-machine interface tools and industrial networks.

PC 5. Ability to understand processes and phenomena in technological complexes of a particular industry (in accordance with specialization), to analyze production and

Co-funded by the Erasmus+ Programme of the European Union

technological systems and complexes as objects of automation, to determine methods and strategies for their automation.

PC 6. Ability to synthesize, design, debug special measuring and control systems, process control and monitoring systems, taking into account the characteristics of production and technological complexes in various fields of activity (in accordance with specialization).

PC 7. Ability to integrate knowledge from other areas, apply a systematic approach and take into account non-technical (economic, legal, social and environmental) aspects when solving engineering problems and conducting research.

PC 8. Ability to conduct patent research in order to ensure patent cleanliness of new design solutions, determine technical level indicators, automated and automatic control systems, their hardware and hardware and software

PC 9. Ability to apply modern methods of automatic control theory for the development of automated control systems for cyber-physical systems.

PC 10. Ability to develop a functional, technical and informational structure of computer-integrated cyber-physical systems depending on technological conditions and requirements for production management systems.

PC 11. Ability to demonstrate special knowledge of network data transfer technologies used in automated systems of various levels and purposes.

PC 12. Ability to reasonably choose and design specialized software and hardware for automation systems of complex technological and organizational and technical objects.

PC 13. Ability to organize installation, commissioning of automation systems of complex technological and organizational-technical objects, to carry out their operation in accordance with international and national standards.

PC 14. Ability to apply modern approaches and methods to the design and development of automation systems of various levels and purposes. Professional proficiency of special software for the implementation of such tasks.

General requirements for learning outcomes in the specialty

RLO1 To be able to apply intelligent control methods to create highly efficient automation cyber-physical systems based on the use of databases, knowledge bases and artificial intelligence methods.

RLO 2. To be able to create highly reliable automation cyber-physical systems based on modern provisions of the theory of reliability, functional safety of software and hardware, analysis and risk reduction in complex systems.

RLO 3. To be able to apply modern methods of modeling and optimization for research and creation of effective control systems for complex technological and organizational-technical objects.

RLO 4. To be able to develop computer-integrated control systems and software and hardware systems based on industrial controllers, human-machine interface tools and industrial information networks.

RLO 5. Have the skills to develop specialized software for microprocessor control systems, programmable controllers and human-machine interface tools.

RLO 6. To be able to analyze and process information, conduct patent research in order to make effective decisions, ensure patent cleanliness of new design decisions, determine the technical level of automated and automatic cyber-physical systems, their hardware and hardware and software.

RLO 7. The ability to analyze production systems in various industries as objects of automation and determine the strategy for their automation.

Co-funded by the Erasmus+ Programme of the European Union

RLO 8. To be able to design and establish special measuring and control systems, taking into account the properties of production and technological complexes.

RLO 9. To be able to apply a systematic approach to accounting for non-technical (economic, legal, social, environmental, etc.) components of the assessment of cyber-physical systems during the process of implementation of control systems for complex technological and organizational-technical objects.

Additional requirements for learning outcomes in the specialty

RLO 10. To be able to apply modern methods of the theory of automatic control for the analysis and synthesis of cyber-physical systems for technological processes and objects.

RLO 12. To be able to apply modern methods of system analysis to research and create effective control systems for complex technological and organizational and technical objects.

RLO 13. To be able to develop the functional, technical and informational structure of cyber-physical systems with complex technological and organizational-technical objects, depending on the existing conditions and requirements for MES production management systems.

RLO 14. To be able to use special knowledge of automation tools, network data transfer technologies used in automated systems of various levels and purposes.

RLO 15. To be able to organize the installation and commissioning of automation cyber-physical systems.

RLO 16. To be able to apply modern approaches to the design, development, modernization and operation of automation cyber-physical systems for various purposes.

RLO 17. To be able to identify, localize and correct errors in the operation of software and hardware of automatic and automated control.

RLO 18. To be able to use modern software tools for the development of automation cyber-physical systems with complex organizational and technical objects.

7.3.3.Duration of the program

Term of study: 1 year 4 months
90 ECTS credits,

Study courses and ECTS distribution

Code	Components of the curricula	Number of credits
	Mandatory curriculum components	
OK1	Business Foreign language	3
OK2	Civil defense and labor protection in the industry	3
OK3	Machine Learning for Cyber Physical Systems and Industry 4.0	6
OK4	Smart manufacturing based on cyber-physical systems	8
OK5	Machine Learning for Cyber Physical Systems and Industry 4.0 (term paper)	2
OK6	Adaptive and Robust Systems	8
OK7	Project approach to the designing of cyber-physical systems	8
OK8	Research practice	6
OK9	Graduate research	22

Co-funded by the Erasmus+ Programme of the European Union

Code	Components of the curricula	Number of credits
OK10	State Examination Committee	1
Total mandatory components		**67**
Selected components of the curricula		
Discipline B1		
B1.1	Modern Information Technologies in Transport	8
B1.2	Transportation Cyber-Physical Systems	8
B1.3	Open-Pit Transport Cyber-Physical Systems	8
Total		**8**
Discipline B2		
B2.1	Patenting and copyright	3
B2.2	Grant writing	3
B2.3	Discipline from another curricula *	3
Total		**3**
Discipline B3		
B3.1	Automation of hydraulic and pneumatic systems	4
B3.2	Cyber-physical systems of mechatronic devices	4
B3.3	Discipline from another curricula *	4
Total		**4**
Discipline B4		
B4.1	Automated complexes of electrical systems	4
B4.2	Information Systems in Industry and Energy Saving	4
B4.3	Discipline from another curricula *	4
Total		**4**
Discipline B5		
B5.1	Computer Mining Technology	4
B5.2	Management Decision Support Systems	4
B5.3	Discipline from another curricula *	4
Total		**4**
Total selected components		**23**
TOTAL SCOPE OF THE CURRICULA		**90**

Co-funded by the Erasmus+ Programme of the European Union

7.3.4. Final assessment

Assessment of educational achievements is carried out on a 100-point (rating), ECTS scale, national 4-point scale ("excellent", "good", "satisfactory", "unsatisfactory") and verbal ("set off", "neglected") systems .

Types of control: current, thematic, periodic, final, self-control.

Forms of control: oral and written interviews, test tasks including computer testing, laboratory reports, presentations, defense of term papers and projects, practice reports, defense of the master's qualification work.

7.3.5. Analysis of the program for the relevance to the EQF level descriptors

HPK - level 8, FQ-EHEA - second cycle, EQF LLL - level 7.

8. Brief analysis of Partners reports results

Partner	Modernisation activities in the study programs	Notes
BSU	Mathematics and Computer Science During Erasmus project we will do: 1. Instead of course "Interaction with embedded devices" new course "Internet of Things" will be introduced. Learning materials for courses "Computer modelling applications", "Internet of Things" will be developed "Mechanics and Numerical Simulation" During Erasmus project we will do: Preparation of new didactic materials for lecture courses "Applied PhysicsDuring Erasmus project we will do: Laboratory practice and Teaching/Learning materials for course "Methods of mathematical modeling of physical processes" will be modernized Practical tasks for course "Methods of mathematical modeling of physical processes" will be developed/modernized Study programs, practical tasks and Teaching/Learning materials for course "Physical applications of functional analysis and group theory" will be developed/modernized.	

Co-funded by the Erasmus+ Programme of the European Union

	Laboratory practices "Computational methods in physics and physical experiment" will be modernized Special laboratory practice "Experimental Research and Computer Modeling of the Physical Kinetics Processes" will be modernized "Computer Physics" During Erasmus project we will do: Development of new and modernization of having didactic materials for lecture courses, laboratory practices and program trainings	
GSU	10 new courses: - Fundamentals of business and legislation in IT - Theoretical Mechanics - Analytical modelling of friction and wear processes - Simulation of the interaction of electromagnetic waves with DNA-like helices - Technologies of laser treatment of materials - Modelling of microwave and THz devices based on metamaterials - Simulation of surface charge distribution in nanostructured materials - Practical statistics for physicists - Hardware and software of networks - Microprocessors and microcontrollers 2 modernised courses: bachelor, masters - Computer simulation of physical systems and processes - Computer systems of analytical calculations	
MSPU	4 new courses and 1 modernised course: - Research tasks in Physics - Computer modelling of physical systems, processes and phenomena - Modern integrated packages for analysis and modelling of processes and systems - Object oriented programming - Quantum electronics and holography Research tasks in Physics 2. Computer modelling of physical systems, processes and phenomena 3. Modern integrated packages for analysis and modelling of processes and systems 4. Object oriented programming	
CNTU	5 new courses in the new master program "Industrial Automation". The program will be accredited by the MEC of Ukraine. - Model-oriented control in Digital Manufacturing - Programming of Automation Systems - Design and Simulation of Power electronics components - Modelling and Measurement of physical processes in Robotics. - Simulation of Manufacturing Environment 2 modernised courses in the bachelor program "Computer systems of automation" - Simulation of electronic circuits - Development of electromechanical robotic systems. Training courses will be developed for Master's students program in "Industrial Automation" (Program Subject Area: Automation and computer-integrated technologies in Digital Manufacturing).	
KNU	3 new master degree courses in the new program "Cyber-physical systems". The program will be accredited by the MEC of Ukraine. - Smart manufacturing based on cyber-physical systems - Machine Learning for Cyber Physical Systems and Industry 4.0 - Transportation Cyber-Physical Systems 4 updated master degree in "Cyber-physical systems" and "Automobiles and Fleet". - Designing	

Co-funded by the Erasmus+ Programme of the European Union

	Computer-Integrated Systems - Adaptive and Robust Systems - Computer modelling of physical processes and systems - Modern Information Technologies in Transport Training courses will be developed for Master's students program in "Cyber-physical systems" (Program Subject Area: Automation and computer-integrated technologies).	
KhNTHU	2 new courses for a master program "Electric Vehicles and Energy-Saving Technologies". The program will be accredited by the MEC of Ukraine. - Energy-saving technologies in transport - The structure of hybrid and electric vehicles 4 modernised courses for master students in "Electric Vehicles and Energy-Saving Technologies": - Electric systems of environmentally friendly vehicles - Methods of planning scientific research on vehicles Mathematical modelling and methods of optimization - Intelligent information technologies and systems in transport Training courses will be developed for Master's students program in "Electric Vehicles and Energy-Saving Technologies". The program will be accredited by the Education and Science of Ukraine. Energy-saving technologies in transport The structure of hybrid and electric vehicles	

Analysis in accordance with the main criteria of the programs evaluation:
Types of the programs – Master, Bachelor
Aims and objectives of the study programs of the partners to be modernized are fully relevant to the level of the program and LOs described
Duration, courses, ECTS distribution correspond to the level of the program, expected results and European standards,
LOs – in full extent reflect the stated aims and mostly correspond to the level of the EQF descriptors

The competences and current situation with the study programs of the partners demonstrate the readiness of the partner Universities to realize those improvements in the programs stated in the Project application. The overall structures of all the programs demonstrate their good enough flexibility for the expected variations and for the correspondence to the Bologna values after these changes.

Weak points and threats – two global: poor English language proficiency and lack of financing; additional specific: opinion that not enough level of competence is given at the first Bachelor level of programs for the correspondence to EQF.

Presence of many study courses of low value of ECTS within one program that could further somehow complicate the opportunity of students exchange within the European market.

Conclusions on the basis of the surveys results

Fields of cyber-physical systems application

Co-funded by the Erasmus+ Programme of the European Union

1. Robotics (4.75) / Production processes (4.72)/ Smart Cities (4.6)
2. Management of production processes (4.52) / Car industry (4.26)/ Transportation systems (4.34)
3. Energy production (3.94)

Modelling/ design / tools

MatLab/Similink software

Purely statistical systems /Monte-Carlo

ANSYS/ COMSOL

Additional areas stated by the industrial partners

- Theory of Probability and Mathematical Statistic
- System Analysis
- Design of Experiments
- Embedded Models
- Model-Oriented Control
- Computer Vision
- Modeling of analogue and digital circuits with transient processes and specific delays of the signal distribution in real technologic processes CMOS (65nm, 45nm)
- Agriculture and accurate farming (сельского хозяйства и точное земледелие)

The survey results allow to conclude that the curricula "Cyber-physical systems" meets the requirements of modern industry

The industrial partners agree with the necessity of the study program modernisation

Therefore, we can expect that the further graduates will get job opportunities at the professional market and correpond to the requirements of the industrial represntatives

The selected study courses for development and /or modernisation basicall correspond to the industrial demands