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Analysis of the survey of professional associations, research institutes and other employers of master graduates

The REPORT

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CONTENT

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1. Introduction

To reform the High Education System in Belarus according to the Bologna process, the Ministry of Education of Belarus requires the High Educational Institutions (HEIs) to reform the curricula from the existing "5 + 1" system to the "4 + 2" system in order to comply with the Bologna system principles. Since academic year 2014-2015, according to a Regulation of the Ministry of Education [1] (year 2012), a part of the HEIs started teaching according to a 4 years' program for the first stage (bachelor degree) and an additional 2 years' program for the second stage of higher education (master degree).

The implementation of Erasmus plus KA1 activities in the exchange of staff and students between European and neighbourhood region is a good basis for implementation of on Bologna principles based study programs in EU and Partners countries. The cooperation agreements signed by partners in the frame of project is a good basis for practical implementation of practical exchange.

The analysis of existing approach in EU and Belarussian universities was done and published, as well as presented and methodological approach was discussed in the international conferences, with focus on education and methodology development. The result of this analysis and international expertise is a number of courses and study books published in e-format.

At the same time, the situation in Belarus is rather different from EU countries, in particular for a number of physics specialities (functional nanomaterials, photonics, applied physics, nanomaterials and nanotechnologies, nanophotonics, etc.) the 5+1 or even the 5+1.5 systems of education did still not change in Belarus. This implies it is really necessary to realize the curricular reforms for both the first and the second stage of education (a 2-years instead of a 1 year mastership). In order to improve the education in physics, these organizational reforms of the curricula need the creation of new training programs. Due to a redistribution of learning branches between the first and second stages of education and also due to the need for practice-oriented human resources and fundamental branches of physical-mathematical sciences, new courses and educational tools are developed.

When considering the first stage of education, a reduction from 5 to 4 years may cause risks associated with the competences of the graduated students i.e. for the trained personnel for scientific research institutes, design engineering bureaus, high-tech enterprises, and universities. Graduates studying only a 4-year educational program will probably have lower qualifications than those who studied the old 5-year programs. Potential employers should take this risk into account.

Traditionally, in Belarus the amount of master-level graduates is very low (approximately 10 %) in comparison with the total amount of graduates. It is very likely that this share will grow up since employers need personnel with a qualification which is at least not lower than the qualification offered by the old 5-year training. At present, 5-year graduates mostly meet the industry and high school requirements. The graduates of the 6-year training cycle are mainly

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employed by scientific research institutes, high-tech enterprises and universities. Considering the experience gained in the European Union, the number of graduates having the entire 6-year training cycle of the "4 + 2" system should increase in order to meet the needs of universities and other employers.

Also inspired by the Bologna process, the latest version of Instruction on Workload of Higher Education Programmes Calculation via System of Credits was approved by the Ministry of Education of the Republic of Belarus in 2015. The instruction treats a credit as a numerical method to quantify the student his workload based on the achievements within his or her study program. At present, the system is already used for students who started their specialist trainings or their master degree programs after 2013. But in reality, it only has sense when realising an academic mobility. It is still not really used for students who resume their studies at their home university. The majority of the university staff and the students are still not aware about the system or do not understand its sense.

In 2015, a project “The Improvement of master-level education in the field of physical sciences in Belarusian universities (Physics)", has been started in order to addresses the above mentioned problems, evolutions and challenges. The project is focused on the development of a standardized program forming the basis of modernized curricula in the field of functional nanomaterials production and photonics for all Belarusian HEIs.

2. Methodology

In this project, we developed innovative curricular promoting industry-oriented, student-centred master-level curricular in the field of physical sciences in Belarus. This approach contains an evaluation by the main stakeholders (students, teachers, researchers, employers, national accreditation institution and the Ministry of Education of Belarus) during the entire project life cycle. The curricula are developed and adjusted according to the stakeholders’ feedback in five stages (see |Fig.1).

- Gap analysis
- Development of new curricular
- Accreditation
- Testing and obtaining feedback from stakeholders
- Analyses and final adjustments

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2.1 Gap analysis

In order to provide an input to the curricular development stage, we evaluated existing courses and training programs in Belarusian universities against the best practice of EU universities and provided a survey of potential employers.

To investigate the specific needs of the labour market in Belarus, a survey of professional associations, research institutes and universities as employers of master graduates has been realized as ex-ante survey in the beginning of the project in February 2016. The survey was developed using different guidelines and EU partners input, which was slightly modified taking into account the educational and cultural traditions of Belarus. The purpose of this survey was to:

- acquire ideas about the market needs of a 2-year practice-oriented master-level education;
- find out how employers judge the qualification requirements for graduates from industry-oriented master programs;
- identify the training requirements of practice-oriented master programs for the planned "4 + 2" system;
- provide input to the new two-years master-level training programs “photonics” and “functional nanomaterials”.

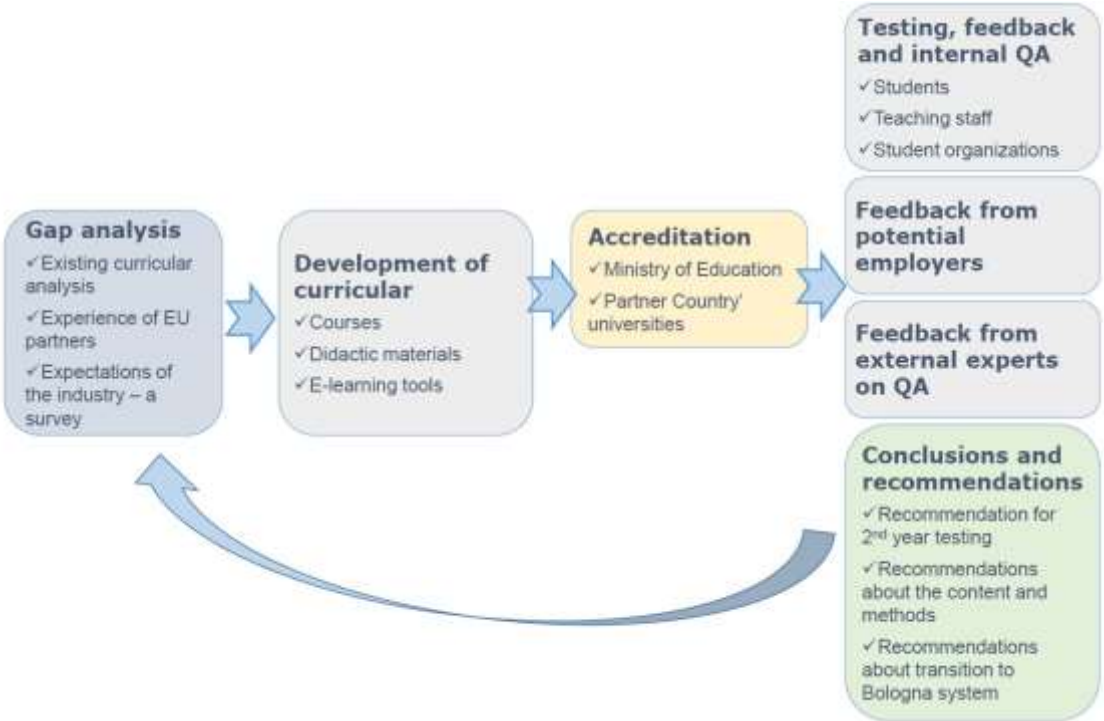

Figure 1. Methodology of development of the curricula.

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The survey involved 8 teams from 4 universities (BSU, GoSU, GrSU, BSTU), the Belarusian Physical Society, the Research Institute for Nuclear Problems of BSU and the Republican Association of Nano-Industry. The survey was divided in three logical parts. The first part is related to the industry – academia secondments and the second part is devoted to the adjustment of the educational tasks to the labour market needs in this sector. The third part is dedicated to the identification of missing skills and abilities. The results of the survey have been used during the development of the curricula content for the new 2-year master students.

According to the opinions of the university teams, it is useful to carry out practice work during the last semester. This practice work can be an internship which is oriented to research activities. Its content should ensure a high scientific level of the master thesis which, in turn, should be a significant backlog for a PhD thesis. The importance of trainings in problem solving needs to increase. These recommendations differ from the existing practices where university hours are mainly dedicated to lectures.

Related to the second group of questions, the survey results indicated which educational disciplines are needed for a successful completion of practice work and the employment of master graduates at universities, scientific research institutions and companies. Most of the respondents commonly marked disciplines associated with programming skills and specializations (75% of the respondents) and with theoretical physics (40 % of the respondents). Approximately 40 % of the respondents have noted the importance of the acquisition of skills in measurement and automation, microcontroller system programming, group symmetry theory, etc.

Related to the identification of missing skills and abilities, some respondents noted the need to establish stable interdisciplinary connections between the blocks of mathematical, physical and special disciplines. About 75 % of the respondents have noted the importance of skills like theoretical calculations, construction of mathematical models for physical processes and phenomena, programming, automation of the experiment.

The results of the survey have been used for the development of the curricula content for the 2-year master students.

2.2 Development of new e-books and integrated courses and accreditation

Electronic course books, didactic materials (guides for laboratory works, lecture synopsises, etc.) for upgrading master-level education in the field of physical sciences (functional nanomaterials, photonics, applied physics, etc.) adjusted to labour market needs were completed and uploaded in an e-library (https://dl.bsu.by) based on the Moodle environment. The names of the e-books:

- Applied physics;

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- Functional nanomaterials;
- Photonics;
- Applied informatics;
- Research towards master thesis.

When considering the e-book on "applied physics", the course materials have been integrated in digital learning environments like Blackboard and Moodle (including multimedia materials). These course materials function as a demo-course to all participants (professors and students).

Based on the e-books, resulting from a collaboration between the three European Union universities and the four Belarusian universities, new courses are integrated in the curricula of the Belarusian universities. More precisely, 11 courses are integrated at BSU, 1 course is integrated at GrSU, 9 courses are integrated at GoSU and 4 courses are integrated at BSTU master level educational programs. These new and renewed courses have been approved by the rectorates of the universities. When considering BSU, the standard master-level study programs have been approved by the Ministry of Education of the Republic of Belarus i.e.

- a 2-year master degree program on functional nanomaterials,
- a 2-year master degree program on nanomaterials and nanotechnologies.

2.3 Testing and evaluation of integrated courses and training programs

These new or renewed courses have also been tested in the autumn semester of academic year 2017-2018 and in the spring semester of academic year 2017-2018. The results of the autumn semester testing are already available.

Two types of questionnaire forms have been prepared: one for students and a second one for the teachers involved in course material testing. The questionnaire form for the students included 11 questions where participants were asked to rate the course material relevance, the way of teaching and according to their perception. The relevance of each of the evaluation criteria was assessed using a Likert scale from 1 (not relevant) to 5 (very relevant). The distance between each scale point is assumed equal which implies a mark 3 represents the neutral value in this scale. A consolidated statistics form on answers given on the tested courses was elaborated by partner universities that pointed out the students their perception about the newly developed courses.

The questionnaire form for the teaching staff was mostly focused on measuring the ability of the students to acquire learning material, to pass tests and exams, and also measuring the teachers their perception related to the new curricula. Both students and teachers' questionnaires

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requested to give answers to the open questions about methods of teaching, to express their opinions and suggest improvements.

The number of polled participants differed due to the number of new courses developed by universities and, of course, the total number of students in each university. For example, in BSU 72 students filled in 111 questionnaires, but Grodno University tested only one single new course implying only 8 students participated in the testing and filled in the forms.

Especially at GoSU and at BSTU students ask for more multimedia materials like audio and video materials in order to stimulate the opportunities for self-study. The teaching staff mainly shares the opinions formulated by the students but they mention that dealing with the diversity among the prior knowledge of the students remains a challenge. Developing additional multimedia materials stimulating opportunities for self-study, as mentioned by the students, can solve the concern of the teaching staff concerning a large diversity among prior knowledge of the students.

2.4 Obtaining a feedback from the stakeholders

Since the potential employers were involved in the development of new curricula throughout the whole life cycle of the project, we arranged a survey at the preparation stage of the project, and at the final stage of the project. For the project team, it was crucially to get an evaluation of the main project deliverables from the experts, who represent the industry and employers.

From 01.02.2018 by 01.03.2018, within the framework of the PHYSICS project, the BSU conducted a survey of experts on the quality of curriculum preparation, courses/laboratory study programs for testing in the 2017-2018 educational year.

For the review, two types of questionnaires were proposed: a curriculum questionnaire and a questionnaire for the evaluation of courses and laboratory study programs. Each questionnaire included two types of questions. One type of questions included information about experts (age, position, professional experience in education, science and industry, gender, etc.). The second list of questions included information concerning the expert's opinion on the quality of curricula and/or study programs and suggestions for improving curricula and study programs.

Each expert, depending on the experience in the field of education, was offered from 2 to 5 approved curricula, courses/laboratory study programs.

The curricula were approved by the Ministry of Education of the Republic of Belarus:

1. Master's degree program 81 03 Functional nanomaterials_2 years

2. Master's degree program Physics of Nanomaterials and Nanotechnologies_1 year

3. Master's degree program 81 02 Photonics_2 of the year 2017

4. Master's degree program 1-31_81_02 Photonics_1 year 2012

Programs of courses and laboratory works (totally 9 pieces) were approved by the rectorate of BSU:

1. Physical chemistry of the surface
2. Optics of nanostructures
3. Spintronics
4. Nanomaterials in power engineering
5. Trends in the development of electronics and electronics
6. Nanotechnology in electronics
7. Optoelectronics and microelectronics
8. Coherent optics and holography
9. Conducting composite nanomaterials

Representatives of the Belarusian consortium, which are members of non-governmental organizations, research institutes, universities and enterprises, who are consumers of BSU graduates in the areas of Functional Nanomaterials, Photonics, Nanomaterials and Nanotechnologies and similar with them, acted as experts:

1. The Belarusian Physical Society (BPO)
2. Republican Association of Nanoindustry (RANI)
3. Research Institute for Nuclear Problems of BSU (RI for NP of BSU)
4. The Belarusian-Japanese private enterprise LOTIS-TII

A total of 9 experts were interviewed, according to the specialization profile of the curricula and programs: 4 from RANI (mainly the laboratories of the Institute of the National Academy of Sciences of Belarus and the heads of the departments/laboratoties of Belarusian universities), 3 from the BPO (the management of the BFO Presidium), 2 from RI NP of BSU (Deputy Director and Leading Scientific Researcher) and 1 of LOTIS-TII PE (leading engineer for production of high-tech products).

The questionnaires, together with the approved curricula and (or) programs, were sent to experts by e-mail and the answers from them were received in the form of scans, and then by mail.

The analysis of the results of answers to questions is presented in the form of two tables. The answers were with a different number of comments on the need to clarify the programs of the courses, which will allow us to tune the programs after the testing is over.

2.5 Preliminary conclusions:

1. 100% of the survey participants approve of the need for the transition of higher education in Belarus to the Bologna 4 + 2 system, which is confirmed by the statistics of answers to questions and explanatory notes to some questions (see tables).

2. 100% of the survey participants approve the need for the introduction of training programs in the specialties "Functional nanomaterials", "Photonics", "Nanomaterials and nanotechnologies".

3. Approximately 90% of the experts interviewed have confirmed the importance of the introduced courses and laboratory works, although the programs themselves have certain comments that will be used to correct (tune) them.

The methods developed and applied in this project facilitated the creation of an integrated, logically connected system of complementary educational approaches. These approaches encouraged:

- to improve the training of master students in physical sciences by practice - oriented master level programmes;
- to improve competences of the teaching/technical staff of Belarusian universities.

The project encouraged Belarussian HEIs to develop new courses for master-level programs and to implement an accreditation at university and national levels. Furthermore, the project provided to Belarusian HEIs:

- experience in the transition from the existing (former Soviet) system to a new system complying with the Bologna principles;
- expertise in the development of master-level programs with a 2 years training cycle in the defined curricula topics;
- inspiration to collaborate with representatives of research institutions and industry for creating curricular which meet the labour market needs in the area of applied physics;
- good practices concerning the development and acquisition of innovative ICT environments, teaching tools, didactic materials dedicated to on-line and web based teaching/learning.

Feedback from stakeholders (students, teachers, researchers, employers, a national accreditation institution) obtained during all project life cycle promoted industry-oriented, student-centred master-level curricular in the field of physical sciences in Belarus.

2.6 Concerns and risks

It should be noted some uncertainty in the organization of the two-year master-level education due to the delay in the adoption of the Education Code in Belarus. This delay means that now there is no complete clarity about future specialties within the framework of the two-year magistracy, as well as the number of master-students recruited every year. Within the existing one-year master's program this amount is very small (e.g. no more than 15 people per year in Faculty of Physics in BSU), whereas in the new Education Code it should be increased to 30-40 people. The delay in adopting the Code will result in an insufficient number of bachelor undergraduates to provide a set of master-students for both specialties simultaneously, since some students will continue to study the 5 + 1 system, not the 4 + 2 system.

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Attachments 1:

Questionnaire
of the peer review of experts by Curricula from professional NGOs, research scientific institutes (RSI), enterprises and universities in the framework of ERASMUS+ Project PHYSICS

The purpose of the survey

In order to bring the system of higher education of Belarus in line with the principles of the Bologna process, the Ministry of Education of the Republic of Belarus (MERB) has set the universities the task of reforming the curricula in connection with the transition from the existing "5 plus 1" system to the "4 plus 2" system. From 2013-2014 academic year, in accordance with the Order of the Ministry of Education No. 389 of 28.05.2012 "On the transition to the differentiated terms of obtaining higher education of the first stage", in the first stage of higher education, universities must begin training in accordance with the 4-year programs, and the second stage - the graduation of masters should be carried out for 2 years of study.

This reduction in the first stage of higher education of the term of training specialists from 5 to 4 years in the field of physics and engineering leads to certain risks in the training of personnel for research institutes (research institutes), design bureaus (DBs) and high-tech enterprises. One of the risks associated with the release of specialists for 4-year programs with actual qualifications, different from those for graduates, prepared for 5-year programs. The second risk is associated with a low proportion of students in the second stage (and graduate) undergraduates in relation to the release of specialists at the first stage of training.

So far, for the "5 plus 1" system, the share of specialists at the first (5 years) and second (1 year) levels of training for physical specialties was planned as 90% and 10%, respectively, which met the needs of the labor market in science, education and high-tech industries. Currently, the qualification of a specialist with 5 years of training is more in line with the requirements of industry, and specialists with a 6-year cycle of training are mainly required in universities, design bureaus and research institutes.

Taking into account the experience of the EU countries, it can be predicted that in the coming years the share of specialists with a 6-year training cycle in the "4 plus 2" system will grow significantly in enterprises

Thus, the question of the development of practical-oriented training in the 4 + 2 system with a 4-year cycle of study at the first stage of higher education (bachelor's degree) and 2-year master's degree at the second stage of higher education becomes urgent. The project 561525-EPP-1-2015-1-LV-EPPKA2-CBHE-JP "Improvement of education at the master's level in the field of physical sciences in Belarusian universities" (acronym PHYSICS) is aimed at this in particular. The project is being implemented in 2015-2018. Belarusian State University (BSU), Grodno State University (Gomel State University) and Belarusian State Technological University (BSTU) within the framework of the Erasmus + European Union program in partnership with the Ministry of Education of the Republic of Belarus, the Belarusian Physical Society (BPO) and the Republican Association of Nanoindustry (RANI), as well as in

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cooperation with associated organizations - the Research Institute for Nuclear Problems of BSU and the Private Belorus-Japan Enterprise "LOTIS-TII".

The aim of the project is to facilitate the transfer of Belarusian universities from the "5 plus 1" education system to the "4 plus 2" system, which should comply with the principles of the Bologna system.

A special goal of the project is to create curricula and study programs of courses/laboratory works in 4 Belarusian universities (BSU, BSTU, GSU, GRGU) corresponding to the 4-year (bachelor) and 2-year (magistracy) on the specialties "Functional nanomaterials" and "Photonics", which are compatible with curricula and educational approaches in EU universities.

The objectives of this survey are:

• Review of curricula in the specialties "Functional nanomaterials" and "Photonics" for a 2-year practical-oriented magistracy with in-depth training.
• Review of the curricula of courses and laboratory works for the specialties "Functional nanomaterials", "Photonics", "Physics" and "Nanomaterials and nanotechnologies" for the training of specialists in the field of physical sciences within the framework of the 4-year (bachelor) and 2-year master's degree) of teaching cycles.
• Accumulation of ideas for the completion of the formation in Belarus of a system of higher education of the European type "4 plus 2", which should comply with the principles of the Bologna process and strengthen the training of specialists for the high-tech industry and modern science.
• Clarifying (comprehending) the requirements that employers (RSIs/enterprises/ universities) impose on the training and qualification programs of graduates of a practice-oriented magistracy;
• Identification of the requirements that employers (RSIs/enterprises/ universities) apply to the process of training bachelors with a 4-year cycle of training and undergraduates with a 2-year training cycle.

The survey data will be used in Belarusian universities to clarify the curricula and study programs of courses/laboratory works aimed at preparing engineering-oriented personnel (bachelors and undergraduates) for High-Tech and science in applied physics, physics, photonics, functional nanomaterials, nanotechnologies and other.

Please give detailed answers to the following questions concerning the developed curricula in the specialties

Professional experience of survey participants

1. What is your area of professional activity?

□ science

□ education

□ production of high-tech products

□ other (denote)

2. Have you had previous or current experience in training specialists in applied physics, physics, photonics, functional nanomaterials, nanotechnologies, etc.?

□ yes

□ no

When you answer "yes", indicate the direction of preparation

3. Have you had previous or current work experience in scientific projects in applied physics, physics, photonics, functional nanomaterials, nanotechnologies, etc.?

□ yes

□ no

If you answer "yes" please specify:

- the scientific direction

- applied direction

Questions on curricula

1. Do you consider it necessary to organize the preparation of bachelors and undergraduates in the 4 + 2 system at Belarusian universities (please briefly substantiate the answer):

□ yes
□ no
□ justify the answer

2. Do you consider it necessary to divide the preparation of undergraduates with a two-year term of study at the universities of Belarus into three components - state, education and elective (according to students' choice):

□ yes
□ no
□ justify the answer

3. Do you consider it necessary to organize training in the universities of Belarus in the following areas:

□ applied physics
□ Physics
□ photonics
□ Functional nanomaterials
□ nanotechnology
□ others (indicate)

4. Do you consider it necessary to include in the curriculum for undergraduates with a two-year period of study the proposed list of disciplines

□ yes

□ no

When the answer is no, indicate which disciplines should be excluded or include and justify your answer

5. Do you think that the schedule of the educational process in the proposed curriculum provides the required level of training for undergraduates with a two-year period of study

□ yes

□ no

When the answer is "no", indicate which sections of the Graphics and why they need to be changed:

□ distribution of activities by year

□ distribution of activities by months

□ the distribution of time between the classroom and the independent training

Justify your answers.

6. Do you think that the Plan of the educational process in the proposed curriculum provides the necessary level of preparation of undergraduates for undergraduates with a two-year cycle

□ yes
□ no
In the answer "No", indicate which sections of the Plan and why they need to be changed:

□ distribution of courses and workshops by semesters
□ Distribution of courses and workshops for the week of the semester
□ the distribution of time between the classroom and the independent training
□ list of public component courses
□ list of courses and laboratory workshops of the institution component of education
□ list of courses and laboratory workshops of the elective component
□ distribution of hours between courses of the public component
□ distribution of hours between the courses of the institution component of education

Justify your answers.

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7. What additional disciplines do you consider necessary to introduce into the curriculum of undergraduates? What disciplines are required to supplement (increase in volume), and which ones to reduce? Justify your answer.

Comments and suggestions

If you have any comments or suggestions about the problem or the content of the questions, please write down your thoughts in this section.

If you do not mind, could you please give us more information about yourself?

Age: 25-30 31-40 41-50 старше 50

Status*:* □ emploee RSI/RSL □ teacher
□ factory worker □ other

Experience of teaching: 3-7 year/ 7-15 year / 15-20 year / >20 year

Experience in science: 3-7 year / 7-15 year / 15-20 year / >20 year

Experience in production: 3-7 year / 7-15 year / 15-20 year / >20 year

_____	_____	_____
position	signature	Family name, Name

Attachment 2

Questionnaire
of the peer review of experts by courses/laboratory works study programs from professional NGOs, research scientific institutes (RSI), enterprises and universities
in the framework of ERASMUS+ Project PHYSICS

The purpose of the survey

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In order to bring the system of higher education of Belarus in line with the principles of the Bologna process, the Ministry of Education of the Republic of Belarus (MERB) has set the universities the task of reforming the curricula in connection with the transition from the existing "5 plus 1" system to the "4 plus 2" system. From 2013-2014 academic year, in accordance with the Order of the Ministry of Education No. 389 of 28.05.2012 "On the transition to the differentiated terms of obtaining higher education of the first stage", in the first stage of higher education, universities must begin training in accordance with the 4-year programs, and the second stage - the graduation of masters should be carried out for 2 years of study.

This reduction in the first stage of higher education of the term of training specialists from 5 to 4 years in the field of physics and engineering leads to certain risks in the training of personnel for research institutes (research institutes), design bureaus (DBs) and high-tech enterprises. One of the risks associated with the release of specialists for 4-year programs with actual qualifications, different from those for graduates, prepared for 5-year programs. The second risk is associated with a low proportion of students in the second stage (and graduate) undergraduates in relation to the release of specialists at the first stage of training.

So far, for the "5 plus 1" system, the share of specialists at the first (5 years) and second (1 year) levels of training for physical specialties was planned as 90% and 10%, respectively, which met the needs of the labour market in science, education and high-tech industries. Currently, the qualification of a specialist with 5 years of training is more in line with the requirements of industry, and specialists with a 6-year cycle of training are mainly required in universities, design bureaus and research institutes.

Taking into account the experience of the EU countries, it can be predicted that in the coming years the share of specialists with a 6-year training cycle in the "4 plus 2" system will grow significantly in enterprises

Thus, the question of the development of practical-oriented training in the 4 + 2 system with a 4-year cycle of study at the first stage of higher education (bachelor's degree) and 2-year master's degree at the second stage of higher education becomes urgent. The project 561525-EPP-1-2015-1-LV-EPPKA2-CBHE-JP "Improvement of education at the master's level in the field of physical sciences in Belarusian universities" (acronym PHYSICS) is aimed at this in particular. The project is being implemented in 2015-2018. Belarusian State University (BSU), Grodno State University (Gomel State University) and Belarusian State Technological University (BSTU) within the framework of the Erasmus + European Union program in partnership with the Ministry of Education of the Republic of Belarus, the Belarusian Physical Society (BPO) and the Republican Association of Nanoindustry (RANI), as well as in cooperation with associated organizations - the Research Institute for Nuclear Problems of BSU and the Private Belarus-Japan Enterprise "LOTIS-TII".

The aim of the project is to facilitate the transfer of Belarusian universities from the "5 plus 1" education system to the "4 plus 2" system, which should comply with the principles of the Bologna system.

A special goal of the project is to create curricula and study programs of courses/laboratory works in 4 Belarusian universities (BSU, BSTU, GSU, GRGU)

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corresponding to the 4-year (bachelor) and 2-year (magistracy) on the specialties "Functional nanomaterials" and "Photonics", which are compatible with curricula and educational approaches in EU universities.

The objectives of this survey are:

• Review of curricula in the specialties "Functional nanomaterials" and "Photonics" for a 2-year practical-oriented magistracy with in-depth training.
• Review of the curricula of courses and laboratory works for the specialties "Functional nanomaterials", "Photonics", "Physics" and "Nanomaterials and nanotechnologies" for the training of specialists in the field of physical sciences within the framework of the 4-year (bachelor) and 2-year master's degree) of teaching cycles.
• Accumulation of ideas for the completion of the formation in Belarus of a system of higher education of the European type "4 plus 2", which should comply with the principles of the Bologna process and strengthen the training of specialists for the high-tech industry and modern science.
• Clarifying (comprehending) the requirements that employers (RSIs/enterprises/ universities) impose on the training and qualification programs of graduates of a practice-oriented magistracy;
• Identification of the requirements that employers (RSIs/enterprises/ universities) apply to the process of training bachelors with a 4-year cycle of training and undergraduates with a 2-year training cycle.

The survey data will be used in Belarusian universities to clarify the curricula and study programs of courses/laboratory works aimed at preparing engineering-oriented personnel (bachelors and undergraduates) for High-Tech and science in applied physics, physics, photonics, functional nanomaterials, nanotechnologies and other.

Please give detailed answers to the following questions concerning the developed curricula in the specialties

Professional experience of survey participants

1. What is your area of professional activity?

□ science

□ education

□ production of high-tech products

□ other (denote)

2. Have you had previous or current experience in training specialists in applied physics, physics, photonics, functional nanomaterials, nanotechnologies, etc.?

□ yes

□ no

When you answer "yes", indicate the direction of preparation

3. Have you had previous or current work experience in scientific projects in applied physics, physics, photonics, functional nanomaterials, nanotechnologies, etc.?

□ yes

□ no

If you answer "yes" please specify:

- the scientific direction

- applied direction

Questions by courses/laboratory works study programs

1. Do you consider the discipline _____

_____

necessary for the learning of students in the specialties "Functional nanomaterials", "Physics of nanomaterials and nanotechnologies", "Photonics" and "Physics"

□ yes

□ no

When you answer "no" - justify your answer

2. Do you agree with the wording of the purpose of this academic discipline:

□ yes

□ no

When you answer "no" - justify your answer

3. Do you agree with the wording of the tasks of this academic discipline:

□ yes

□ no

When you answer "no" - justify your answer

4. Do you agree with the formulation of the requirements for the qualification of students after training in this discipline (what should he know, be able, than to own):

☐ yes
☐ no

When you answer "no" - justify your answer

5. Do you agree with the formulation of the main competencies for which the development of this discipline is directed:

☐ yes

☐ no

If you answer "no" - specify which of the competencies need clarification or modification

6. Do you agree that the ratio of the number of hours and hours for managed self-study (URS) of students in this program contributes to the full assimilation of this discipline

☐ yes

☐ no

When you answer "no" - explain

7. Do you agree that the ratio of the number of hours and hours for managed self-study (URS) of students in this program contributes to the full assimilation of this discipline

☐ yes

☐ no

When you answer "no" - explain

8. o you agree with the content of the training material in the program of this discipline or laboratory workshop

☐ yes

☐ no

If you answer "no" - specify which sections of the course need changes or additions

9. Do you agree with the content of the training material in the program of this discipline or laboratory workshop

☐ yes

☐ no

If you answer "no" - specify which sections of the course need changes or additions

10. o you agree with the content of the training material in the program of this discipline or laboratory workshop

☐ yes

☐ no

If you answer "no" - specify which sections of the course need changes or additions

11. o you agree with the Educational-methodical map of this discipline

☐ yes

☐ no

If you answer "no" - specify which sections of the map need changes or additions

12. Do you agree with the list of recommended basic literature in the Information and Methodical part of the discipline or laboratory program

☐ yes

☐ no

At the answer "no" - specify the list of the main literature

13. Do you agree with the list of recommended basic literature in the Information and Methodical part of the discipline or laboratory program

☐ yes

☐ no

At the answer "no" - specify the list of the main literature

14. Do you agree with the list of recommended basic literature in the Information and Methodical part of the discipline or laboratory program

☐ yes

□ no

At the answer "no" - specify the list of the main literature

15. Do you agree with the list of recommended secondary literature in the Information and Methodical part of the course or laboratory program

□ yes

□ no

At the answer "no" - specify the list of auxiliary literature

16. What measures to control the quality of mastering knowledge in this discipline, given in the Information and Methodical part of the course program, do you consider necessary and sufficient:

□ testing

□ test works

□ writing essays

□ Workshops

□ additional (specify, which)

17. What measures to control the quality of mastering knowledge in this discipline, given in the Information and Methodical part of the course program, do you consider necessary and sufficient:

□ testing

□ test works

□ writing essays

□ Workshops

□ additional (specify, which)

18. Do you agree with the recommendations on quality control of knowledge assimilation and certification

□ yes

□ no

If you answer "no" - make suggestions on how to change this section of the program

19. Do you agree with the recommendations on quality control of knowledge assimilation and certification

- yes
- no

If you answer "no" - make suggestions on how to change this section of the program

20. Do you agree with the recommendations on quality control of knowledge assimilation and certification

- yes
- no

If you answer "no" - make suggestions on how to change this section of the program

21. What, in your opinion, is the program of this discipline aimed at:

- formal use of knowledge
- development of critical thinking
- use of methods of cause-and-effect analysis
- development of practical experience and skills
- development of new competencies,
- development of independent thinking
- development of the ability for non-standard approaches in solving problems and making decisions
- other

22. What, in your opinion, is the importance of this discipline.

23. Emphasize 3 main points that you consider to be the most important for mastering this discipline.

24. Do you have any suggestions for further improvement of this discipline?

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Comments and suggestions

If you have any comments or suggestions about the problem or the content of the questions, please write down your thoughts in this section.

If you do not mind, could you please give us more information about yourself?

Age: 25-30 31-40 41-50 старше 50

Status: □ emploee RSI/RSL □ teacher
□ factory worker □ other

Experience of teaching: 3-7 year/ 7-15 year / 15-20 year / >20 year

Experience in science: 3-7 year / 7-15 year / 15-20 year / >20 year

Experience in production: 3-7 year / 7-15 year / 15-20 year / >20 year

_____ _____ _____

position signature Family name, Name

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Attachment 3

Summary Table 1
of the answers "yes" and "no" to the questions in questionnaires for validated curricula

N	Question	Yes	No	The main reasons for the response
1.	**Do you consider it necessary to organize the training of bachelors and undergraduates in the universities of Belarus in the 4 + 2 system**	+++++++++		1. It is advisable from the point of view of increasing the period of study for those who finish the master's degree and from an economic point of view for introducing bachelor's degree 2. The transition to such an educational system will make it comparable with the system abroad (integration into the international educational space), which in turn will enable students and their teachers to be more mobile and participate in the scientific and educational activities of the countries working in accordance with the Bologna system.
2.	**Do you consider it necessary to divide the preparation of muster students with a two-year term of study in the universities of Belarus into three components - state, university and elective (at the choice of students)**	++++++++	+	1. I do not see the expediency of dividing into three components. There are no clear advantages to this

				separation.
3.	**Do you consider it necessary to organize training in the universities of Belarus in the following areas:**			
	□ Applied Physics	++++		
	□ Physics	++		
	□ Photonics	+++		
	□ Functional Nanomaterials	++		
	□ nanotechnology	++++		
	□ others: *physics of particles, atomic nuclei and high energies; modern mathematical physics*	+ +		
4.	**Do you consider it necessary to include in the curriculum for undergraduates with a two-year period of study the proposed list of disciplines**	+++++++++	+	Fundamentals of quantum field theory: electrodynamics and solid state physics
5.	**Do you think that the schedule of the educational process in the proposed curriculum provides the necessary level of training for undergraduates with a two-year period of study**	+++++++++		I believe that the proposed schedule of the educational process fully corresponds to the goals and objectives of the educational process. The proposed curriculum is comprehensive and balanced.
6.	**Do you think that the Plan of the educational process in the proposed curriculum provides the necessary level of preparation of undergraduates for undergraduates with a two-year cycle**	++++++++	+	The plans of the educational process, in my opinion, should provide the necessary level of training for masters, provided that it is strictly observed and all tasks are accomplished

Ответы на вопросы «Какие дополнительные дисциплины Вы считаете необходимым ввести в программу обучения магистрантов? Какие дисциплины требуется дополнить (увеличить в объеме), а какие сократить?
Answers to the questions "What additional disciplines do you consider necessary to introduce into the curriculum of master students? What disciplines are required to supplement (increase in volume), and which ones to reduce?

applied physics	physics	photonics	functional nanomaterials	nanotechnologies	other
					• Microcosm and the Universe. • Fundamentals of quantum field theory • Electrodynamics and Solid State Physics
					• I consider it appropriate to include an information technology course (computer simulation using modern software packages). • It is necessary to increase the number of hours for learning a foreign language (technical English)

***Justify your answer**:*

1. The inclusion of an information technology course will allow undergraduates to familiarize themselves with the most common and useful software packages for solving issues in the field.
2. Increase the number of hours for learning a foreign language, because knowledge of English is an integral part of the work of a modern scientist.

Comments and suggestions

1. It is necessary to increase the number of hours of a foreign language,

2. It is necessary to expand the practice of using information technology

Attachment 4

Summary Table 2
of the answers "yes" and "no" to the questions in questionnaires for courses/laboratory study programs

N	Question	Yes	No	The main reasons for the response
1	Do you consider necessary for the learning of students in the specialties "Functional nanomaterials", "Physics of nanomaterials and nanotechnologies", "Photonics" and "Physics" using disciplines:			
	•Physics and Chemistry of Surface	+		The discipline "Physics and Chemistry of Surface" is necessary for the learning of students in the specialties "Functional nanomaterials", "Physics of nanomaterials and nanotechnologies" and also can be recommended for the study by the specialties "Photonics" and "Physics".
	•Optics of nanostructures	+		
	•Spintronics	+		
	•Nanomaterials in Power	+		
	•Tendencies in development of electronics and electronic production		+	It is necessary for the preparation of students on the specialty "Physics of nanomaterials and nanotechnologies". It can be also recommended for the specialty "Functional nanomaterials" and is not needed for the specialties "Photonics" and "Physics".
	•Nanotechnologies in electronics		+	It is necessary for the preparation of students on the specialty "Physics of nanomaterials and nano-technologies", it can be recommended for the specialty "Functional nanomaterials" and is not needed for the specialties "Photonics" and "Physics".
	•Opto- and microelectronics	+		
	•Coherent optics and holographie	+		

	•Conductive composite nanomaterials	+		
2	Do you agree with the wording of the purpose of this academic discipline (If you answer "no" - justify your answer):			
	•Physics and Chemistry of Surface	+		
	•Optics of nanostructures	+		
	•Spintronics	+		
	•Nanomaterials in Power	+		
	•Tendencies in development of electronics and electronic production	+		
	•Nanotechnologies in electronics	+		
	•Opto- and microelectronics	+		
	•Coherent optics and holographie		+	It is necessary for the preparation of students on the specialty "Physics of nanomaterials and nano-technologies", it can be recommended for the specialty "Functional nanomaterials" and is not needed for the specialties "Photonics" and "Physics".
	•Conductive composite nanomaterials	+		
		+		
3	Do you agree with the wording of the tasks of this academic discipline (If you answer "no" - justify your answer):			
	•Physics and Chemistry of Surface		+	The explanatory note does not clearly define the objectives of this course.
	•Optics of nanostructures		+	
	•Spintronics	+		
	•Nanomaterials in Power	+		
	•Tendencies in development of electronics and electronic production	+		
	•Nanotechnologies in electronics	+		
	•Opto- and microelectronics	+		
	•Coherent optics and holographie	+		

	•Conductive composite nanomaterials	+		
		+		

Attachment 5

Summary Table
of professional experience of participants in the survey on courses/laboratory study programs

N	Question	Yes	No		Scientific direction	Applied direction
•	What is your area of professional activity: a. Science b. Education c. Production of High-Tech Products d. other	 ++++ ++++ +			 + +	 +
•	Have you had previous or current experience in training specialists in the field of: • Applied Physics • Physics • Photonics • Functional nanomaterials of nanotechnologies • other When you answer "yes", indicate the direction of preparation	 ++ ++++ ++ +++ +		Production of high-tech devices		
•	• Have you had previous or current experience in scientific projects in the field of: • Applied Physics	 ++++				

	• Physics • Photonics • Functional nanomaterials of nanotechnologies • other If yes, indicate the scientific or applied direction	++++ ++ +++ +	 +		+	+

Attachment 6

Summary Table
of the composition of participants in the analysis of courses/laboratory study programs

Age	**25-30**	**31-40**	**41-50**	**older 50**
			++	+
Status	employee of SRI / SRL	teacher	worker of enterprise	other
	++++	++++	+	
Teaching experience	3-7 years	7-15 years	15-20 years	>20 years
	++			+++
Work experience in science	3-7 years	7-15 years	15-20 years	>20 years
		++	++	++++
Work experience in production	3-7 years	7-15 years	15-20 years	>20 years

	– – – – – – – –		+	+
Position		• Leading researcher of SRI	• Leading Engineer in Private Enterprise • Deputy Director of Research Institute	• Head of the Center of the National Academy of Sciences of Belarus • Executive Director of RANI • Head of Department of the University • Professor • Scientific Secretary of BPO

4	Do you agree with the wording of the requirements for the qualifications of students after training on this academic discipline (what should he know, be able, than to own) (In the answer "no" - justify your answer):			
	• Physics and Chemistry of Surface	+		The requirements need to be adjusted in accordance with the comment on paragraph 3
	• Optics of nanostructures		+	
	• Spintronics	+		
	• Nanomaterials in Power	+		
	• Tendencies in development of electronics and electronic production	+		
	• Nanotechnologies in electronics	+		
	• Opto- and microelectronics	+		
	• Coherent optics and holographie	+		
	• Conductive composite nanomaterials	+		
5	Do you agree with the formulation of the core competencies to which the discipline is intended to be mastered? (In the answer "no" - specify which of the competencies need clarification or modification):			
	• Physics and Chemistry of Surface		+	The requirements need to be adjusted in accordance with the comment on paragraph 3
	• Optics of nanostructures		+	
	• Spintronics	+		
	• Nanomaterials in Power	+		
	• Tendencies in development of electronics and electronic production	+		
	• Nanotechnologies in electronics	+		
	• Opto- and microelectronics	+		

	• Coherent optics and holographie • Conductive composite nanomaterials	+		
6	Do you agree that the ratio of the number of hours and hours for managed self-study (URS) of students in this program contributes to the full assimilation of this discipline (When the answer is "no" - give an explanation):			
	• Physics and Chemistry of Surface	+		
	• Optics of nanostructures	+		
	• Spintronics	+		
	• Nanomaterials in Power	+		
	• Tendencies in development of electronics and electronic production	+		
	• Nanotechnologies in electronics	+		
	• Opto- and microelectronics	+		
	• Coherent optics and holographie	+		
	• Conductive composite nanomaterials			
7	Do you agree with the content of the training material in the program of this discipline or laboratory work (If you answer "no" - specify which sections of the course need amendments or additions):			
	• Physics and Chemistry of Surface		+	The curriculum does not adequately disclose the aspects of chemical reactions and molecular processes at the surface, the formation of nanoscale and nanostructured coatings, insufficient attention is paid to the physico-chemical and computational methods for the study structure and properties of the surface.
	• Optics of nanostructures		+	The Drude theory is archaic from the modern point of view. The interaction of electromagnetic waves with metals must be stated from the point of view of modern quantum theory, for example, as described in the book by M.I. Ryazanov,

				Electrodynamics of Condensed Matter, Moscow: Nauka 1984. There is a qualitative exposition. I think that the formulation "Mi scattering" is not very correct. There is the problem MI-one of the few exactly solvable problems of diffraction of a plane electron waves on bodies of finite dimensions, in this case on a ball. Indeed, this problem is solved by Mi. Rayleigh scattering is one of the limits that gives a foreseeable expression for the intensity.. The second is possible and should be called the scattering of Mi, but it seems to me more correctly to write down in the program: scattering on the sphere, Rayleigh approximation, approximation of large bodies (in comparison with the wavelength of the incident radiation). The Maxwell equations for the medium, and then for the absorbing medium.
		+		
		+		
			+	The section "Spintronics" should be included in the study material.
	• Spintronics • Nanomaterials in Power • Tendencies in development of electronics and electronic production • Nanotechnologies in electronics • Opto- and microelectronics		+	The section "Spintronics" should be included in the study material.
			+	- Sections 1 - 3 are too large. It is expedient to combine them in one more compact section, which could be called ”The Element base of semiconductor microelectronics”. - Section 4. Thermoelectric power converters in this program is superfluous. - The program does not include such important for optoelectronics sections as Solid-state radiation sources, Solid-state radiation detectors, Optical waveguides, Optoelectronic information transmission systems.

		+		
	• Coherent optics and holographie • Conductive composite nanomaterials	+		
8	Do you agree with the Educational-Methodical Map of this discipline (If you answer "no" - specify which sections of the map require changes or additions):			
	• Physics and Chemistry of Surface		+	The training map should be finalized in accordance with the above remarks
	• Optics of nanostructures		+	From my point of view, changes should be made to Sections 2.1, 2.2 and 3.1 in accordance with the remarks made above. The Lorentz model would also follow a modern approach based on the concept of collective excitations-quasiparticles, focusing on the same MI. Ryazanov, Electrodynamics of Condensed Matter, Moscow: Nauka 1984
		+		
	• Spintronics	+		
	• Nanomaterials in Power		+	The section "Spintronics" should be included in the study material.

	• Tendencies in development of electronics and electronic production		+	The section "Spintronics" should be included in the study material.
	• Nanotechnologies in electronics • Opto- and microelectronics		+	The map of the discipline must be amended to eliminate the remark on the previous paragraph. It is also advisable to plan practical or laboratory works on this discipline
		+		The List of recommended basic literature is enough
	• Coherent optics and holographie • Conductive composite nanomaterials	+		The List of recommended basic literature is enough

9	Do you agree with the List of recommended basic literature in the Information/ Methodical Part of the discipline or laboratory work (If you answer "no" - specify the list of main literature):			
	• Physics and Chemistry of Surface	+		The List of recommended basic literature is enough
	• Optics of nanostructures		+	I can not comment because I am not an expert in this particular field, but I would think that M.I. Ryazanov, Electrodynamics of condensed matter
	• Spintronics	+		The list of recommended basic literature is enough
	• Nanomaterials in Power	+		The List of recommended basic literature is enough
	• Tendencies in development of electronics and electronic production		+	In the list of main literature it is expedient to include publications with the stamp of the Ministry of Education of the Republic of Belarus: - Textbook: VE Borisenko, AI Vorobyeva, AL Danilyuk, EA Utkina, Nanoelectronic: Theory and Practice (Binom, Moscow, 2013), 366 p. - Tutorial: VE Borisenko, AL Danilyuk, DB Migas, Spintronics (Laboratory of Knowledge, Moscow, 2017), 229 p. However, the list of main literature should not contain more than 3 titles.
	• Nanotechnologies in electronics		+	In the list of main literature it is expedient to include publications with the stamp of the Ministry of Education of the Republic of Belarus: - Textbook: VE Borisenko, AI Vorobyeva, AL Danilyuk, EA Utkina, Nanoelectronic: Theory and Practice (Binom,

				Moscow, 2013), 366 p. - Tutorial: VE Borisenko, AL Danilyuk, DB Migas, Spintronics (Laboratory of Knowledge, Moscow, 2017), 229 p. However, the list of main literature should not contain more than 3 titles.
	• Opto- and microelectronics		+	The List of the main literature should be revised taking into account the changes in the program for the remarks noted above.
	• Coherent optics and holographie • Conductive composite nanomaterials	+		The List of recommended basic literature is enough
		+		The List of recommended basic literature is enough
10	Do you agree with the List of recommended supporting (additional) literature in the Information and Methodical part of the course program or laboratory work (If youk answer "no" - specify the list of supporting literature):			
	• Physics and Chemistry of Surface	+		The List of recommended supporting (additional) literature is enough
	• Optics of nanostructures		+	I would consider it necessary to include additional literature in the List: 1. 1. S.V. Izmailov. Course of electrodynamics. Uchpedgiz -1962, 440 s. (there is on the Internet). 2. 2. M.I. Ryazanov, Electrodynamics of Condensed Matter, Moscow: Nauka 1984, 303 p. 3. 3. C. Huert, R. Thomson Solid State Physics M.: Mir 1969. 558 p. 4. 4. F.I. Fedorov Optics of anisotropic media. Myu: URSS 2004, 380 p. 5. 5. F.I. Fedorov The theory of gyrotropy. Minsk, Science

				and Technology -1976, 456 p. 6. 6. S.V. Gaponenko. Optical Processes in Semiconductor Nanocrystallites (Quantum Dots) // Physics and Technology of Semiconductors. - 1996. - T. 30. - P. 577-619. 8. Gaponenko S.V. Optical properties of semiconductor nanocrystals. - Cambridge University Press, 1998. 7. 9. Gaponenko S.V., Kalt H., Woggon U. Semiconductor Quantum Structures. Optical Properties. Part 2 .. - Springer, 2004. 8. 10. Gaponenko S.V. Introduction to Nanophotonics. - Cambridge University Press, 2010. Graduates of the University (undergraduates are not exception) do not know monographic literature well.
	• Spintronics • Nanomaterials in Power • Tendencies in development of electronics and electronic production • Nanotechnologies in electronics	+		The List of recommended supporting (additional) literature is enough
		+		The List of recommended supporting (additional) literature is enough
			+	The list of auxiliary literature should be clarified taking into account that part of the titles according to the previous proposal will be supplemented by publications from the list of main literature. It should not exceed 5 titles.
			+	The list of auxiliary literature should be clarified taking into account that part of the titles according to the previous proposal will be supplemented by publications from the list of main literature. It should not exceed 5 titles.
		+		CThe list of supporting literature should be reviewed taking into account the changes in the program for the remarks noted above.
		+		The List of recommended supporting (additional)

				literature is enough
	• Opto- and microelectronics • Coherent optics and holographie • Conductive composite nanomaterials	+		The List of recommended supporting (additional) literature is enough

11	What activity to control the quality of mastering the knowledge in this discipline, given in the Information/Methodical Part of the course program, do you consider necessary and sufficient:			
	☐ testing	++++		
	☐ control works	+++		
	☐ writing essays	++++		
	☐ Workshops	+++		
	☐ additional (specify, which)	+++		Oral Interview
12	Do you agree with the recommendations for monitoring the quality of learning and attestation (When you answer "no" - make suggestions for changing this section of the program):			
	• Physics and Chemistry of Surface	+		
	• Optics of nanostructures	+		
	• Spintronics	+		
	• Nanomaterials in Power	+		
	• Tendencies in development of electronics and electronic production	+		
	• Nanotechnologies in electronics	+		
	• Opto- and microelectronics	+		
	• Coherent optics and holographie	+		
	• Conductive composite nanomaterials	+		
13	What is directed, in your opinion, is the program of this discipline:			

	□ formal use of knowledge □ development of critical thinking □ use of methods of cause-and-effect analysis □ development of practical experience and skills □ development of new competencies, □ development of independent thinking □ development of the ability for non-standard approaches in solving problems and making decisions □ other	++ ++ +++ ++++ + ++++ + +		application of scientific and theoretical knowledge for solving practical problems application of scientific and theoretical knowledge
14	What, in your opinion, is the importance of this discipline:			
	• Physics and Chemistry of Surface	+		Allows students to form the most complete picture of surface phenomena and expand their professional horizons.
	• Optics of nanostructures	+		Discipline paves the way for the formation of a high-class specialist in the field of nanophysics. Nanophysics is important for creating new technologies
	• Spintronics	+		The importance of discipline is based on the possibility of using the acquired practical skills and theoretical knowledge in the development of new spintronic devices and devices, as well as in predicting their characteristics.
	• Nanomaterials in Power	+		The possibility of applying theoretical knowledge obtained by students to solve specific practical problems of energy, as well as in forecasting new properties of nanostructured materials in accordance with the needs of the energy sector
		+		In the formation of students' holistic ideas about modern electronics and the trends of its development.
		+		In the formation of students' holistic ideas about modern electronics and the trends of its development.

	• Tendencies in development of electronics and electronic production • Nanotechnologies in electronics • Opto- and microelectronics	+		In the formation of students basic knowledge of the principles of operation of the basic structures of opto- and microelectronics, the relationship between the properties of the materials used and the working parameters of these structures
		+		The possibility of applying the theoretical knowledge received by students to solve specific practical problems
	• Coherent optics and holographie • Conductive composite nanomaterials	+		In the formation of students basic knowledge of the mechanisms of electric transport in metal-insulator nanocomposites in a wide range of temperatures and frequencies
15	Emphasize 3 main points that you consider the most important for mastering this discipline:			
	• Physics and Chemistry of Surface			1. Performing tests to consolidate the acquired knowledge. 2. Application of multimedia teaching aids. 3. Use of electronic surface properties in the work of modern nanoelectronic devices
	• Optics of nanostructures			1. The combination of theoretical knowledge and the ability to analyze on this basis physical phenomena and processes. 2. Forming a systematic approach to understanding physical processes and phenomena. 3. Skill in practice to use the acquired knowledge.
	• Spintronics			1. The possibility of improving the practical skills of the experiment when working on real physical installations; 2. Opportunities to participate in seminars and presentations; 3. The possibility to participate in the development of real prototypes of spintronic devices in cooperation with

				industrial enterprises
	• Nanomaterials in Power			1. A deep theoretical analysis of the structure and properties of nanomaterials, as well as the physico-chemical processes taking place in them 2. Detailed study of the needs of modern energy in new materials, areas of their application 3. Development of students' ability to think critically and methods of cause-and-effect analysis to correlate the possibilities of material-management and energy needs with the purpose of creating new materials for solving practical problems
	• Tendencies in development of electronics and electronic production			1. The connection of the achievements of modern electronics with the successes in physics and chemistry. 2. Historical aspects of the emergence and industrial development of achievements that determine the modern level of electronics. 3. Examples of the latest achievements.
	• Nanotechnologies in electronics			1. The connection of the achievements of modern electronics with the successes in physics and chemistry. 2. Historical aspects of the emergence and industrial development of achievements that determine the modern level of electronics. 3. Examples of the latest achievements.
	• Opto- and microelectronics		.	1. Examples of specific elements of opto- and microelectronics. 2. Comparative analysis of advantages and limitations of the main structural elements of opto- and microelectronics 3. Understanding the physics of the basic elements of opto- and microelectronics.
				1. The connection between the achievements of modern optics and holography with the successes in physics. 2. Historical aspects of the emergence and industrial development of achievements that determine the current

				level of optics and holography. 3. Examples of the most recent achievements
	• Coherent optics and holographie • Conductive composite nanomaterials			1. Deep theoretical analysis of the percolation properties of metal-dielectric composite materials 2. Deep theoretical analysis of the relationship between the structure and conductive properties of nanomaterials, 3. Deep theoretical analysis of the mechanisms of electrical conductivity of nanocomposite metal-insulator materials over a wide range of temperatures and frequencies
16	Do you have any suggestions for further improvement of this discipline?			
	• Physics and Chemistry of Surface			The curriculum of this discipline should be adjusted in accordance with the comments on paragraph 7.
	• Optics of nanostructures			A number of topics need to be presented at a more modern level.
	• Spintronics			It is necessary to expand the range of materials, with which galvanomagnetic effects and mechanisms of electrotransfer in magnetic fields are considered in the disciplina, taking into account modern nanostructured and nanocomposite objects.
	• Nanomaterials in Power			It is necessary to increase the number of hours of this discipline, because, in view of the broad subject of the course, the program contained in the content of the curriculum can be implemented only in an amount sufficient to get acquainted with new materials and their properties (superficially), suitable for energy needs. For a detailed study of the processes that determine the physicochemical

	• Tendencies in development of electronics and electronic production • Nanotechnologies in electronics • Opto- and microelectronics • Coherent optics and holographie • Conductive composite nanomaterials			properties of substances and materials and the prospects for their application in modern energy, a more in-depth analysis of the structure and properties of nanomaterials is needed, which will allow us not only to assess the possibilities of using existing materials in the energy sector, but also to design new ones, significant properties.
				In terms of improving this discipline, it is sufficient to clarify the program of its study in accordance with the remarks noted above.
				In terms of improving this discipline, it is sufficient to clarify the program of its study in accordance with the remarks noted above.
				It is enough to clarify the program of this discipline in accordance with the recommendations mentioned above.
				No comments
				There are no comments and suggestions.

Comments and suggestions

Course	Remarks
Physics and Chemistry of Surface	With the exception of the recommendations noted in paragraphs 1.3.7, there are no comments
Optics of nanostructures	No
Spintronics	The educational-methodical map of the discipline is hammered by lecture classes, while the mastering of the material requires a certain number of seminars and practical exercises (in accordance with the proposals expressed in paragraph 15)
Nanomaterials in Power	1. The notion of "nanooptimization" applied to solar panels, biomass growing regimes, components of transmitting devices in the description of the content of educational material should be deciphered. 2. The wording of the skills of students formed as a result of the training within the framework of this course requires little correction. So the second point would be more understandable in the phrase "making ... conclusions about the methods of possibilities and directions of their practical application in modern energy". 3. Perhaps, it would be necessary to increase the number of hours allocated for the study of materials for energy storage, in particular electric, in connection with the urgency of this problem both in the world and for the Republic of Belarus, as well as the complexity of the structure of modern materials suitable for this application , and the physicochemical processes taking place in them.
Tendencies in development of electronics and electronic production	It is enough to clarify the program of this discipline in accordance with the recommendations mentioned above.
Nanotechnologies in electronics	It is enough to clarify the program of this discipline in accordance with the recommendations mentioned above.
Opto- and microelectronics	Remarks, other than those stated above, I do not have
Coherent optics and holographie	No comments
Conductive composite nanomaterials	There are no comments and suggestions.