# MINISTER OF EDUCATION, SCIENCE AND SPORT OF THE REPUBLIC OF LITHUANIA

## ORDER
## ON APPROVAL OF THE DESCRIPTOR OF THE GROUP OF STUDY FIELDS OF COMPUTING

21 December 2022 No. V-1995
Vilnius

In accordance with Paragraph 11 of Article 53 of the Law on Higher Education and Research of the Republic of Lithuania:

1. I approve the Descriptor of the Group of Study Fields of Computing (enclosed).

2. I determine that the higher education institutions have to adjust their study programmes to the Descriptor of the Group of Study Fields of Computing approved by Clause 1 hereby until 01 September 2021.

Minister of Education, Science and Sport Jurgita Šiugždinienė

APPROVED
by Order No. V-195 of the Minister of
Education, Science and Sport of the
Republic of Lithuania of 21 December 2022

# DESCRIPTOR OF THE GROUP OF STUDY FIELDS OF COMPUTING

## CHAPTER I
## GENERAL PROVISIONS

1. The Descriptor of the Group of Study Fields of Computing (hereinafter – Descriptor) regulates the special requirements for the study programmes in the study fields of informatics (B01), information systems (B02) software engineering (B03), and informatics engineering (B04) that belong to the group of study fields of computing (B). The Descriptor regulates the studies in the listed fields that belong to the group of study fields of computing (hereinafter – studies of computing) in the scope not covered by the General Requirements for the Studies approved by Order No. V-1168 of the Minister of Education and Science of the Republic of Lithuania of 30 December 2016 "On approval of the General Requirements for the Studies."

2. The Descriptor was prepared with consideration to recommendations of such organisations as ACM (Curricula Recommendations, ACM. https://www.acm.org/education/curricula-recommendations), IEEE (Access the Computing Industry's Top Guides for Standards and Practices, IEEE Computer Society. https://www.computer.org/education/bodies-of-knowledge) and EQANIE (Euro-Inf Programme Outcome for informatics and related programmes, EQANIE. https://eqanie.webs.upv.es/wp-content/uploads/2019/09/Euro-Inf_New_Programme_Outcomes_for_Accreditation_2015-10-12.pdf).

3. The Descriptor's requirements shall be applied to short study cycle (hereinafter the " short studies"), college and the university studies of the first and second cycle conducted as full-time and part-time studies.

4. Short studies are carried out according to the programmes of study in the fields of informatic engineering, information systems and software engineering. They must comply with the Professional Standard for the Information and Communication Technology Sector, approved by the Director of the Centre for the Development of Qualifications and Vocational Training (CQDVT) by Order No V1-206 of 22 December 2020 ,,On the approval of the Professional Standard for the Information and Communication Technology Sector".

5. After completing short studies the qualification that is in conformity with the fifth level of the Lithuanian Qualifications Framework and the European Qualifications framework for lifelong learning attested by a study certificate issued by the higher education institution and entitling to engage in professional activities and/or to continue their studies at a higher education institution is awarded.

6. After completion of the studies of computing, the professional bachelor's/ bachelor's or master's degree in computing that is in conformity with the sixth/seventh level of the Lithuanian Qualifications Framework and the European Qualifications Framework for lifelong learning, attested by the diploma of the professional bachelor's / bachelor's or master's degree and diploma supplement issued by the higher education institution are awarded.

7. The scope of a short study programme may be 90 or 120 study credits. On-the-job training in a real workplace shall be 30 study credits (if the study programme is 90 study credits) or 40 study credits (if the study programme is 120 study credits). At least 5 study credits must be allocated for the applied project or the applied project combined with the final examination.

8. The volume of a college study programme may be 180 or 210 study credits. The total volume of the internship shall be no less 30 study credits. At least 9 credits have to be awarded to the final thesis (project); in case when studies are interdisciplinary, it is recommended to carry out one joint final thesis (project) that would integrate learning outcomes of both study fields.

9. The volume of a university study programme of the first cycle may be 210 or 240 study credits. The total volume of the internship shall be no less than 15 study credits. At least 15 credits shall be given to the final thesis (project); in case when studies are interdisciplinary, it is recommended to carry out one joint final thesis (project) that would integrate learning outcomes of both study fields.

10. The volume of the study programme of the second cycle may be 90 or 120 study credits. At least 30 study credits have to be allocated to the final thesis (project).

11. There are no special requirements established in the Descriptor for the persons, who want to be admitted to the short study and first cycle programmes.

12. It is recommended to admit the persons, who have at least the professional bachelor's degree and who have completed the university bridging courses, or who have at least the bachelor's degree, into the studies of the second cycle. The list of modules (subjects) of the bridging courses and the content of the studies shall be established by the higher education institution. The volume of these courses shall not exceed 60 study credits. The learning outcomes achieved in the studies of the first cycle, bridging courses or through informal education have to satisfy the requirements set by the higher education institution and ensure the ability to study in the study programmes of the second cycle in the group of study fields of computing.

13. The graduates of computing must have achieved the learning outcomes of the selected study field from the group of study fields of computing. The aim of a specific study programme should be formulated in accordance with the requirements for the general and specific learning outcomes of the field of study, as well as for the cycle and type of study (university or college), and the formulation of the aim should include only the key words and concepts recommended for the cycle and type of study.

14. The general goal of all computing studies is to develop a skilled and responsible personality with professional knowledge and skills to carry out practical tasks in the areas of professional activity, able to work individually or in a team, to learn independently for personal and professional development.

15. Special objectives of short studies in computing:

15.1. in the study field of informatics engineering to develop personality that would be able to apply informatics and electronic methods, engineering principles and technologies in order to design, implement, maintain and test secure computer systems;

15.2. in the study field of information systems to develop personality that would be able to create, install, operate, improve, update and control secure information systems;

15.3. in the study field of software engineering to develop personality that would be able to develop, operate and maintain software for various areas.16. The general objective of the first and second cycle in all computing studies is to develop a comprehensively educated, educationally and scientifically receptive, ethically responsible, communicative, creative and entrepreneurial personality, capable of independent learning, for continuous personal and professional development, capable of working independently in team, taking initiative and assuming personal responsibility.

16. The general goal of all computing studies of the first and second cycles is to develop a fully educated, receptive to education and science, ethically responsible, communicative, creative and entrepreneurial personality, capable of independent learning, in order to achieve continuous personal and professional development, capable of working independently in team, taking initiative and taking personal responsibility.

17. Special objectives of the first and second cycle in computing studies are the following:

17.1. in the study field of informatics – to train a personality, that would be able to compete in the market of rapidly changing technologies, products or services, to design and install secure software, to search for new application methods of computer systems and effective solutions for

processing of data and information intended to solve relevant problems of different professional activities;

17.2. in the study field of informatics engineering – to train a personality, that would be able to compete in the market of rapidly changing technologies, products or services, to apply the informatics and electronic methods, engineering principles and technologies in order to design, implement, support, develop, inspect and assess secure computer systems and networks that may be used to solve relevant problems of different professional activities;

17.3. in the study field of information systems – to train a personality, that would be able to compete in the market of rapidly changing technologies, products or services, to create, install, operate, improve, update and control secure information systems intended to solve relevant problems of different professional activities;

17.4. in the study field of software engineering – to train a personality, that would be able to compete in the market of rapidly changing technologies, products or services by applying engineering in the disciplined and quantifiable mode to the development, operation and maintenance of software intended for various areas that may be used to solve relevant problems of different professional activities.

18. The study programmes of two study fields may be university study programmes of the first cycle, where the studies belong to the group of study fields of computing and any other study field are matched, when the activities and methods of studies are based on the interaction between the subjects in the interdisciplinary environment. After completing such study programme, the persons shall be awarded qualification degrees in both groups of study fields, or the degree in computing if both study fields belong to the group of study fields of computing.

19. The interdisciplinary study programmes may be college and university study programmes of the first and the second cycle, where the predominant field belongs to the group of study fields of computing, and the other field is from any other group. After completing such study programme, the persons shall be awarded qualification in computing.

## CHAPTER II
## CONCEPT AND SCOPE OF THE STUDY FIELD

20. The computing is analysing the processes and systems of computerised information processing: their theory, analysis, modelling, design, implementation, and application.

21. The core of the group of study fields of computing consists of the following areas of knowledge: higher mathematics, discrete structures, algorithms and their complexity, programming paradigms and languages, computer architecture, operating systems, computer networks, security of information and information technologies, including the aspects of cyber security (as defined in standard ISO/IEC 27032:2012 Information technology - Security techniques - Guidelines for cybersecurity, https://www.iso.org/standard/44375.html), human-computer interaction, computerised management of data and information, fundamentals of software development, and social aspects.

22. The knowledge of computing may cover such perspective areas as intelligent systems, machine learning, big data, robotics, internet of things and services, cloud computing, virtual and augmented reality.

23. Concept and scope of the study fields in the group of study fields of computing:

23.1. study field of informatics:

23.1.1. is oriented to computing: theory, analysis, modelling, design, implementation and application, including a wide range of issues from theory of algorithms up to smart systems and solving of other problems related to computing and information processing. The study field of informatics is related to three main categories of activities: software development and installation, finding new ways of application of computer systems, and development of efficient methods of computation;

23.1.2. covers the following areas of theoretical and practical knowledge: discrete structures, algorithms and their complexity, computer architecture, operating systems, computer networks and

communication, parallel and distributed computing, graphics and visualisation, human-computer interaction, security of information and information technologies, management of data and information, programming paradigms and languages, fundamentals of software development, systems modelling, and intelligent systems;

23.2. study field of informatics engineering:

23.2.1. studies more extensively the application of the informatics and electronic methods, engineering principles and technologies in order to design, implement, maintain, develop, inspect and assess computer systems and networks, by applying the requirements and criteria of functionality, efficiency, reliability, and security, including cyber security;

23.2.2. the knowledge consists of the core knowledge of computing and additional knowledge of informatics engineering. The additional knowledge of informatics engineering covers areas of cloud computing and virtualisation, internet of things, cyber security, programming of specialised computing devices, robotics, multimedia, virtual and augmented reality, and digital signal processing;

23.3. study field of information systems:

23.3.1. covers information technologies and systems intended to collect, present, process and manage data, information and knowledge of organisations necessary to ensure effective management of organisation's or person's activities. By consolidating software, hardware, human resources and information flows of organisations, information systems provide information services necessary to manage those organisations, plan their activities, and make decisions;

23.3.2. covers the following main areas of theoretical and practical knowledge: development, installation, operation, improvement, updating and management of information systems and information technologies needed for those systems to function, management of information systems projects, analysis of business processes and identification of information needs, specification of requirements and design of information systems, installation, operation and maintenance of information systems, development of databases and data repositories, business data analytics, architecture of organisations, information security;

23.4. study field of software engineering:

23.4.1. studies more extensively in the systematic, disciplined and quantifiable application of engineering to the development, operation and maintenance of the software intended for various areas, including its improvement;

23.4.2. fundamental knowledge related to the software requirements, design, construction, testing, maintenance, configuration management, quality, software engineering management, process, models and methods, professional practice and economics. Understanding the reconciliation of different functional and qualitative requirements is very important.

24. All the study programmes of computing may have specialisations. The specialisations are formed by including the knowledge in the study field that deepens or expands modules (subjects) of the group of study fields of computing into the study programme.

25. Graduates of computing must be ready to work as programmers, testers, administrators, architects, analysts, quality assurance specialists, consultants of information and communication technologies (ICT), managers of ICT product, service or project, and other professionals in the ICT area working individually, in private, public and non-governmental sectors, or they can continue studies in the third cycle.

26. The studies of computing have to prepare the students for independent lifelong learning that will enable them not to restrict themselves to current technologies and to accept the future challenges.

## CHAPTER III
## GENERAL AND SPECIAL LEARNING OUTCOMES

27. Having completed the college studies in the group of study fields of computing, the graduates will have achieved the learning outcomes listed in Annex 1 hereto.

28. Having completed the university studies of the first cycle in the group of study fields of computing, the graduates will have achieved the learning outcomes listed in Annex 2 hereto.

29. Having completed the studies of the second cycle in the group of study fields of computing, the graduates will have achieved the learning outcomes listed in Annex 3 hereto.

30. Having completed the short studies in the group of study fields of computing, the graduates will have achieved the learning outcomes listed in Annex 4 hereto.

## CHAPTER IV
## TEACHING, LEARNING AND ASSESSMENT

31. The teaching, learning and assessment have to be based on the concept of study programmes of certain fields and learning outcomes and they have to be in compliance with the fundamental knowledge in the field of computing and the content of the latest scientific achievements. The teaching, learning and assessment activities have to be organised in such a way that the students would be able to achieve the learning outcomes provided in the study programme and to use all the available resources and sources.

32. The learning environment of the higher education institution is under continuous impact of changes in the field of computing. Therefore, assessment of novelties in the field of computing and their integration into the process of studies are very important. The foundation of successful implementation of the studies is competent and qualified teachers, who understand clearly that the purpose of studies is to teach the students to learn and systemise knowledge. The teachers have to be able to improve the content of studies, to choose suitable teaching and assessment methods directed to the student, and to create new, more effective teaching methods that would have positive impact on the learning outcomes.

33. The teaching methods have to train understanding of conceptual fundamentals of computing, to provide knowledge and skills of analysis, design and implementation, technological and methodological skills, context of economic, legal, social and ethical environment, and to increase the professional competence.

34. The activities and methods of studies have to comply with the lifelong learning (continuous learning) concept that demands for training of the understanding about importance of lifelong learning in the process of studies already. The students should be encouraged to acquire learning skills and to learn responsibly.

35. The study process must be flexible and include a variety of study methods to enable students to achieve the intended programme outcomes. Study methods must be clearly defined, effective and varied, and must be regularly reviewed and improved in the light of developments in the field of computing. Self-study assignments must be appropriate to the learning outcomes of the programme of study, and must motivate and educate students to plan and allocate their study time and material resources (libraries, laboratories, equipment, etc.) in a rational manner.

36. The specific nature of computing programmes requires appropriate study methods and flexibility in their application, combining traditional (lecture, laboratory work, seminar, essays, presentation) and non-traditional ("guest lecture", "guest lecture", "guest lecture", teamwork, case studies, problem-based learning, role-playing games, and simulations) study methods.

37. Short studies must be based on the application of knowledge and skills in practice and the development of general, social and personal abilities acquired through practical activities (internships, field trips, etc.).

38. The college studies must include research work, studies must be based on the application of knowledge and skills in practice as well as the development of general social and personal skills acquired through practical activities (internships, field trips, etc.).

39. The university studies have to include scientific research application of knowledge and skills in practice, and training of social and personal abilities. In the second cycle of studies, the

students have to get involved into the scientific research activities (conferences, projects, research practice, etc.).

40. Internships are a valuable and compulsory part of short study, college and first-cycle university studies. The purpose of a internship (cognitive, vocational, educational, research) is to ensure that the knowledge and skills acquired in the internship are combined with practical activities in the internship placement, in order to consolidate, apply and improve the skills acquired in the course of studies. The study programmes have to assure appropriate organisation of internship consisting of preparation and instruction of the students, preparation of practical tasks, organisation of supervision or continuous feedback, maintenance of close contact with the supervisor in the internship placement, and reporting of outcomes.

41. Internationality is an important aspect of computing studies. It is recommended to teach several modules (subjects) in English, to invite foreign teachers to give lectures, to promote international long-term and short-term inbound and outbound mobility of the students.

42. The assessment procedure and strategy of the learning outcomes have to be recorded in the documents of higher education institution. They should be used to formulate assessment procedures of individual modules (subjects) of the study programmes stating the methods and modes used to assess implementation of the outcomes of the study programmes (the whole programme or its individual module/subject).

43. The assessment system of the learning outcomes has to enable observing, how the students succeed in pursuing the purpose and outcomes of the study programme (the whole programme or its individual module/subject), timely diagnosing of deviations, and assuring the feedback. The level of the student's achievements has to be determined while assessing his/her learning outcomes in accordance with the pre-set assessment criteria. The assessment procedure, the assessment system and the assessment criteria have to be based on the principles of validity, reliability, clarity, expedience and impartiality.

44. At the beginning of each semester, the university teachers have to inform the students about the study procedure by introducing thorough curriculum of the taught module (subject), its goal, expected learning outcomes, their assessment structure (influence of the interim tests on final grade, in case of what outcomes the subject (module) has to be repeated or the test has to be retaken, etc.), and the assessment criteria.

45. When the students' achievements are assessed, it is necessary to assure the feedback by providing the students with the information about their learning outcomes and substantiation of the grade. It is also necessary to assure the feedback to the teacher from the students, so that the effectiveness of the teaching process could be improved together with the teaching quality. The students have to receive timely appropriate feedback about their works. The evaluation of the done works and achievements of studies has to be supported by constructive comments based on clear assessment criteria.

## CHAPTER V
## REQUIREMENTS FOR IMPLEMENTATION OF STUDY PROGRAMMES

46. The higher education institution must have academic and non-academic staff, material, methodical and information resources sufficient to implement the study programmes.

47. The study programme may be implemented if it is taught by competent and qualified teachers, who are well familiar with the future work conditions of the graduates and who are able to help the students to get ready for the future professional or academic work.

48. The teachers' competence is assessed according to their scientific, pedagogical, expert and practical experience, using the criteria and requirements established by higher education institutions. Teachers have to devote part of their working time to conducting scientific research, studying and teaching innovations in the fields of science and technology.

49. The study programme has to be improved continuously, with regard to the changes in the science and study field. The persons executing the programme have to make sure that new relevant topics would be included into the taught modules (subjects).

50. Practical examples and situations have to be presented to the students so that they would learn about adaptability of the studied modules (subjects) and needs of the labour market. It is recommended to enter into contracts for internships of students with the stakeholders, who would commit to grant work places to the students or who would give an opportunity for the student to get internships.

51. The short studies end with applied project, or with applied project and final examination, which must be based on the knowledge and skills acquired during the studies and must reflect the student's achievement of the learning outcomes and readiness to work in the qualification awarded.

52. The studies of first and second cycles end in the final thesis (project), the defence whereof is public:

52.1. the final thesis (project) of the college studies has to be based on the knowledge and abilities acquired in the course of studies and to manifest the student’s ability to analyse the cases of work practice in the studied study field in the group of study fields of computing, to offer and implement the solutions of work improvement;

52.2. the final thesis (project) of the university studies of the first cycle has to be based by independent applied researches and application of knowledge in the studied study field in the group of study fields of computing, or it has to be prepared as a project that discloses the acquired abilities in conformity with the purpose of the study programme;

52.3. the final thesis (project) of the university studies of the second cycle has to be based by scientific and independent applied researches and application of knowledge in the studied study field in the group of study fields of computing, or it has to be prepared as a project that discloses the acquired abilities in conformity with the purpose of the study programme;

52.4. the assessment commission of the final thesis (project) has to be formed from competent specialists in the study field – scientists, professional practicians, representatives of stakeholders. The number of commission members cannot be smaller than 5.

53. General requirements for material facilities:

53.1. the number of lecture halls, laboratories, other teaching premises and places in them, their arrangement and layout have to be in compliance with the studying needs and hygiene and safety requirements;

53.2. the infrastructure of information technologies has to meet the studying needs, it has to be prepared and available to all the participants of the study process;

53.3. the teaching material and bibliographical sources have to be available in library and/or electronic environment.

54. The support to students includes academic, psychological, social and material (as much as possible) support. It should be endeavoured at:

54.1. encouraging and motivating the students to get involved in the academic and research activities;

54.2. creating conditions for the students with special needs to study.

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Annex 1 to the Descriptor of the Group of Study Fields of Computing

## Learning Outcomes of College Studies of Computing

| Group of learning outcomes | Study field | Learning outcomes – ability |
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| **1. Knowledge and its application** | **1.1. All fields** | 1.1.1. To explain the essential facts, concepts, theories, and mathematical methods relevant to operation of computers, their hardware and software, its characteristics and practical application possibilities, computer communication and applied solutions related to important historical, current and possible future trends in computer sciences.<br>1.1.2. To explain the principles of algorithm construction and analysis, programming paradigms, languages and technologies, principles of human-computer interaction, typical stages of software life-cycle, and methods of software development and maintenance.<br>1.1.3. To explain how commercial, industrial, economic and social contexts affect professional practice defined by ethical norms and regulated by legal requirements, including data protection, intellectual property rights, contracts, safety of products, responsibility and other related issues.<br>1.1.4. To apply knowledge in the group of study fields of computing for development of applied informatics solutions of concrete professional problems that meet security and other relevant quality criteria. |
| | **1.2. Informatics** | 1.2.1. To explain the all-encompassing processes of digitization and computing, as well as the evolution of the field of informatics in connection with a specific specialty.<br>1.2.2. To explain concepts and methods of data processing and analysis, system modelling, optimisation, and the artificial intelligence. |
| | **1.3. Informatics engineering** | 1.3.1. To explain the methods, how to create computer and other specialised digital equipment, its construction and operation principles, and application to solve particular tasks. |
| | **1.4. Information systems** | 1.4.1. To explain the essential facts, concepts, and theories related to information systems, their development and maintenance, operation of organisations, analysis and modelling of business processes, management of risks and business computerisation projects, and assurance of information security.<br>1.4.2. To explain the principles of storage, management, search, analysis, extraction, visualisation and security assurance of data and information, methods and technologies of design, |

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| | | management, implementation and administration of databases and data repositories. |
| | **1.5. Software engineering** | 1.5.1. To explain software specification, design, testing and documentation, software engineering management, processes, models and methods. |
| **2. Research skills** | **2.1. All fields** | 2.1.1. To describe the problem of professional activities in the studied study field from the group of study fields of computing.<br>2.1.2. To prepare the data and information needed to solve particular professional problem in the studied study field from the group of study fields of computing, by examining various sources.<br>2.1.3. To analyse the data, information and solutions required to solve the particular professional problem in the study field from the group of study fields of computing according to particular criteria.<br>2.1.4. To evaluate the data and information collected to solve the particular professional problem in the study field from the group of study fields of computing and to substantiate the decisions by reasoned conclusions and recommendations. |
| **3. Special abilities** | **3.1. Informatics** | 3.1.1. To apply software lifecycle models, development and maintenance methods, development environments and tools to application software development projects in typical and emerging areas.<br>3.1.2. To model real-world problems using formal methods of informatics and estimating the complexity of the problem.<br>3.1.3. To select appropriate models, algorithms, data structures, data management, software development and maintenance methods for traditional and new IT applications projects in typical software life cycle stages.<br>3.1.4. To methodically prepare a specification, project or other documentation required for the development of a product or service in the field of informatics.<br>3.1.5. To implement a product or service in the field of informatics to solve a particular problem of professional activity, taking into account the functional and non-functional requirements. |
| | **3.2. Informatics engineering** | 3.2.1. To apply relevant methods of informatics and electronic engineering for formulation and solution of applied tasks of various areas.<br>3.2.2. To select software and hardware for creation of new systems or improvement of the already present systems. |

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| | | 3.2.3. To implement the specialised software for computer systems in application of actual standards, typical life-cycle stages and project management methods.<br>3.2.4. To evaluate the computer systems according to the criteria of productivity, security and reliability.<br>3.2.5. To implement maintenance and development of computer systems properly.<br>3.2.6. To prepare a specification, a project or other documentation needed to create a product or service in the area of informatics engineering. |
| | **3.3. Information systems** | 3.3.1. To apply various information systems life-cycle models as well as systems development and maintenance methods, environment and tools in the projects of typical information systems development.<br>3.3.2. To select suitable models, environments and tools of information systems development and maintenance for the typical life-cycle stages and for the project management.<br>3.3.3. To analyse the business processes of organisations by determining the needs of an organisation and of its information systems' users that are related to improvement of organisation's business activities with the help of information technologies.<br>3.3.4. To prepare the specification of requirements, system design and other documentation necessary to create, install, develop, use, and administer the information system.<br>3.3.5. To implement the information system that solves a professional problem, taking into consideration the organisational and technological environment, possible solution alternatives, and specified functional and non-functional requirements. |
| | **3.4. Software engineering** | 3.4.1. To apply software life cycle models, development, maintenance and project management methods, standards, development environments and tools, programming paradigms and algorithms in the projects of typical software systems.<br>3.4.2. To select suitable software development and maintenance tools, applied for typical life cycle stages and project management.<br>3.4.3. To model functional and non-functional requirements for the software product or service.<br>3.4.4. To design software system architecture, components, user interface and testing programmes according to the functional and non-functional requirements set to the software system.<br>3.4.5. To prepare a specification, a project and other documentation needed for software construction, installation, development, use and administration. |

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| | | 3.4.6. To implement the software product or service to solve a particular professional problem, according to the functional and non-functional requirements set to the software system.<br>3.4.7. To verify quality of the software system, its individual components and user interface. |
| **4. Social abilities** | **4.1. All fields** | 4.1.1. To communicate professionally in the official state and at least one foreign language with the audience of specialists.<br>4.1.2. To work in teams, acting in compliance with principles and rules of professional and ethical behaviour as well as social responsibility. |
| **5. Personal abilities** | **5.1. All fields** | 5.1.1. To learn independently in pursuit of continuous personal and professional development.<br>5.1.2. To work independently and responsibly, to take the initiative and to assume personal responsibility.<br>5.1.3. To demonstrate creativity when solving tasks and problems of the professional activities. |

Annex 2 to the Descriptor of the Group of Study Fields of Computing

**Learning Outcomes of First Cycle University Studies of Computing**

| **Group of learning outcomes** | **Study field** | **Learning outcomes – ability** |
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| **1. Knowledge and its application** | **1.1. All fields** | 1.1.1. To explain consistently the essential facts, concepts, theories and mathematical methods relevant to operation of computes, their hardware and software, its characteristics and practical application possibilities, computer communication and applied solutions related to important historical, current and possible future trends in computer sciences.<br>1.1.2. To explain consistently the principles of algorithm construction and analysis, programming paradigms, languages and technologies, principles of human-computer interaction, typical stages of software life-cycle, and methods of software development and maintenance.<br>1.1.3. To explain consistently how commercial, industrial, economic and social contexts affect professional practice defined by ethical norms and regulated by legal requirements, including data protection, intellectual property rights, contracts, safety of products, responsibility and other related issues.<br>1.1.4. To apply knowledge in the group of study fields of computing for development of applied informatics solutions of current professional problems that meet security and other relevant quality criteria. |
| | **1.2. Informatics** | 1.2.1. To explain consistently the comprehensive processes of digitization and computation, developments in the field of informatics and possible future directions in informatics and related fields.<br>1.2.2. To explain consistently concepts and methods of data processing and analysis, system modelling and optimisation, and artificial intelligence. |
| | **1.3. Informatics engineering** | 1.3.1. To explain consistently the methods, how to create computer and other specialised digital equipment, its construction and operation principles, and application to solve particular tasks. |
| | **1.4. Information systems** | 1.4.1. To explain consistently the essential facts, concepts, and theories related to information systems, their development and maintenance, operation of organisations, analysis and modelling of business processes, management of risks and business computerisation projects, and assurance of information security. |

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| | | 1.4.2. To explain consistently the principles of storage, management, search, analysis, extraction, visualisation and security assurance of data and information, methods and technologies of design, management, implementation and administration of databases and data repositories. |
| | **1.5. Software engineering** | 1.5.1. To explain consistently software specification, design, testing and documentation, software engineering management, processes, models and methods. |
| **2. Research skills** | **2.1. All fields** | 2.1.1. To describe at different levels of abstraction the problem of professional activities in the studied study field from the group of study fields of computing.<br>2.1.2. To prepare the data and information needed to solve particular professional problem in the studied study field from the group of study fields of computing, by using most effective methods and examining various sources.<br>2.1.3. To analyse the data, information and solutions required to solve the particular professional problem in the study field from the group of study fields of computing according to various criteria and using effective methods.<br>2.1.4. To evaluate critically the collected and obtained data, information, results and developed solutions by providing reasoned conclusions and recommendations. |
| **3. Special abilities** | **3.1. Informatics** | 3.1.1. To apply the models of software life-cycle, methods, environments and tools of software development and maintenance in the projects oriented to typical and perspective applications.<br>3.1.2. To model real-world problems by using formal methods of informatics and estimating the complexity of the problem.<br>3.1.3. Select appropriate models, algorithms, data structures, data management and software development and maintenance methods for traditional and new IT applications projects in typical software life cycle stages.<br>3.1.4. Methodically prepare a specification, project or other documentation required for the development of a product or service in the field of informatics.<br>3.1.5. Implement a product or service in the field of informatics to solve an important problem of professional activity, taking into account the functional and non-functional requirements. |
| | **3.2. Informatics engineering** | 3.2.1. To apply relevant methods of informatics and electronic engineering for formulation and solution of applied tasks of various areas.<br>3.2.2. To select software and hardware for creation of new systems or improvement of the already present systems. |

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| | | 3.2.3. To implement properly the specialised software for computer systems in application of actual standards, typical life-cycle stages and project management methods.<br>3.2.4. To evaluate the computer systems according to the criteria of productivity, security and reliability.<br>3.2.5. To plan and implement maintenance and development of computer systems properly.<br>3.2.6. To prepare methodically a specification, a project or other documentation needed to create a product or service in the area of informatics engineering. |
| | **3.3. Information systems** | 3.3.1. To apply various models of information systems life-cycle, as well as systems development, integration and maintenance models, environments and tools in the projects of development and improvement of typical and newly emerging information systems.<br>3.3.2. To select suitable models, environments and tools of information systems development and maintenance for the typical life-cycle stages and for the project management.<br>3.3.3. To model the organisations' architecture and its business processes by determining the needs of an organisation and of its information systems' users that are related to improvement of organisation's business activities with the help of information technologies.<br>3.3.4. To prepare methodically the specification of requirements, system design and other documentation necessary to create, install, develop, use, and administer the information system.<br>3.3.5. To implement the information system that solves a professional problem, taking into consideration the organisational and technological environment, possible solution alternatives, and specified functional and non-functional requirements. |
| | **3.4. Software engineering** | 3.4.1. To apply software life cycle models, development, maintenance and project management methods, standards, development environments and tools, programming paradigms and algorithms in the projects of application software systems for typical and newly emerging areas.<br>3.4.2. To select suitable software development and maintenance tools, applied for life cycle stages and project management.<br>3.4.3. To model functional and non-functional requirements for the software product or service.<br>3.4.4. To design software system architecture, components, user interface and testing programmes according to the functional and non-functional requirements set to the software system. |

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| | | 3.4.5. To prepare methodically a specification, a project and other documentation needed for software construction, installation, development, use and administration.<br>3.4.6. To implement the software product or service to solve a particular professional problem, according to the functional and non-functional requirements set to the software system.<br>3.4.7. To evaluate quality of the software system, its individual components and user interface. |
| **4. Social abilities** | **4.1. All fields** | 4.1.1. To communicate professionally in the official state and at least one foreign language with various audiences.<br>4.1.2. To work effectively in teams, acting in compliance with principles and rules of professional and ethical behaviour as well as social responsibility. |
| **5. Personal abilities** | **5.1. All fields** | 5.1.1. To learn systematically and independently in pursuit of continuous personal and professional development.<br>5.1.2. To work independently, systematically and responsibly, to take the initiative and to assume personal responsibility.<br>5.1.3. To demonstrate creativity when solving tasks and problems of the professional activities. |

Annex 3 to the Descriptor of the Group of Study Fields of Computing

**Learning Outcomes of Second Cycle University Studies of Computing**

| **Group of learning outcomes** | **Study field** | **Learning outcomes – ability** |
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| **1. Knowledge and its application** | **1.1. All fields** | 1.1.1. To explain in detail the concepts and scientific principles related to computing and based on the results of fundamental or applied scientific research. |
| | **1.2. Informatics** | 1.2.1. To explain techniques, methods and limitations of their application in the field of informatics.<br>1.2.2. Critically evaluate the comprehensive processes of digitization and computing, the evolution of the field of informatics, as well as possible future directions in connection with informatics and related fields, and scientific research.<br>1.2.3. To generalize the methods of systems modelling, data processing and analysis, artificial intelligence and machine learning.<br>1.2.4. To apply general knowledge of computing deepened or expanded in the study field of informatics, as well as creating solutions for problems in scientific or professional activity and conducting scientific research. |
| | **1.3. Informatics engineering** | 1.3.1. To explain applicable techniques and methods for the area of informatics engineering and identify their limitations.<br>1.3.2. To generalise the meaning and context of solved engineering tasks and performed research in informatics engineering.<br>1.3.3. To apply deepened knowledge of informatics engineering or broadened knowledge of computing in general for solution of professional problems and performance of scientific research and development. |
| | **1.4. Information systems** | 1.4.1. To explain the innovative techniques, technologies and methods applied in the area of engineering of information systems, their application possibilities and limitations.<br>1.4.2. To apply deepened knowledge of information systems engineering or broadened knowledge of computing in general, to develop solutions of scientific, organisational, or professional problems and to carry out scientific research. |
| | **1.5. Software engineering** | 1.5.1. To explain comprehensively the techniques and methods applied in the study field of software engineering, their application possibilities and limitations. |

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| | | 1.5.2. To explain comprehensively software specification, design, testing and documentation, software engineering management, process models and methods.<br>1.5.3. To apply deepened knowledge of the study field of software engineering to the development of solutions that may be used to solve scientific or professional problems and to perform scientific research. |
| **2. Research skills** | **2.1. All fields** | 2.1.1. To define in detail and at different levels of abstraction the scientific or professional problem in the studied study field from the group of study fields of computing and its complexity, taking into consideration the importance of relevant legal, commercial, industrial, economic and/or social contexts.<br>2.1.2. To analyse the scientific or professional problem in the studied study field from the group of study fields of computing described by unreliable or incomplete data and specifications, and their possible solutions, using most effective methods.<br>2.1.3. Based on the research data, to select the most suitable solution of the scientific or professional problem in the studied study field from the group of study fields of computing that is needed to manage a complex situation.<br>2.1.4. To evaluate critically the data, information, and results collected and obtained in the course of research, as well as developed and alternative solutions of the scientific or professional problems in the studied study field from the group of study fields of computing, and their impact on environment, by providing reasoned conclusions and recommendations. |
| **3. Special abilities** | **3.1. Informatics** | 3.1.1. To model real-world problems using formal methods of informatics, assessing the context and uncertain situations, integrating knowledge of informatics and other fields as needed.<br>3.1.2. To model real-world problems using formal methods of informatics to investigate and solve new, complex, insufficiently detailed problems, taking into account relevant business, security, industrial, social and other environmental constraints.<br>3.1.3. To methodically prepare a research specification, a draft solution to investigate and solve a new, complex, insufficiently defined problem.<br>3.1.4. To create an innovative artefact To create an innovative artifact by applying the chosen methods of the study field of informatics to investigate and solve a new, complex, insufficiently defined problem, taking into account the functional and non-functional requirements.<br>3.1.5. Substantiate the developed innovative solutions and operational strategies based on the acquired knowledge of mathematics, informatics and related fields. |

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| | **3.2. Informatics engineering** | 3.2.1. To formulate complex tasks of various areas through integration of relevant knowledge in informatics and other fields, and innovative methods.<br>3.2.2. To apply creatively the appropriate methods to solve the tasks of informatics engineering and to perform the scientific research.<br>3.2.3. To assess as an expert the present products and services in the field of informatics engineering, the products and services under creation, and their documentation. |
| | **3.3. Information systems** | 3.3.1. To apply the methods of computing in new areas related to engineering of information systems, taking account of relevant commercial, safety, industrial, social, and environmental constraints.<br>3.3.2. To select the methods relevant in the context of the studies of the group of study fields of computing in order to examine and solve new, complex problems that are not sufficiently defined, and that are related to engineering of information systems.<br>3.3.3. To model information systems engineering related innovative artefacts and their operational context, and to determine the artefacts users' needs concerning the improvement of activities, for which the artefacts are intended.<br>3.3.4. To prepare methodically the research specification and/or solution project in order to examine and solve a new, complex problem that is not sufficiently defined and that is related to the engineering of information systems.<br>3.3.5. To develop an innovative artefact in order to examine and solve a new, complex problem that is not sufficiently defined and that is related to the engineering of information systems using the selected methods of computing and taking account of the problem's organisational and technological environment, possible alternative solutions, and specified functional and non-functional requirements. |
| | **3.4. Software engineering** | 3.4.1. To apply the effective and automated models, techniques and methods of software engineering in new application areas, taking account of relevant commercial, security, industrial, social and other constraints.<br>3.4.2. To select relevant software models, methods and techniques for researching and solving new, complex, insufficiently defined problems.<br>3.4.3. To model functional and non-functional requirements for the artefact intended to research and solve a new, complex, insufficiently defined problem.<br>3.4.4. To design an artefact and its quality assurance tools by applying automated methods and techniques. |

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| | | 3.4.5. To implement the artefact to research and solve a new, complex, insufficiently defined problem.<br>3.4.6. To evaluate quality of the software products, services and software engineering processes. |
| **4. Social abilities** | **4.1. All fields** | 4.1.1. To communicate effectively and professionally in the official state and at least one foreign language with various audiences.<br>4.1.2. To work effectively in teams and to manage them, acting in compliance with principles and rules of professional and ethical behaviour as well as social responsibility. |
| **5. Personal abilities** | **5.1. All fields** | 5.1.1. To learn systematically and independently in pursuit of continuous personal, professional and scientific development.<br>5.1.2. To work independently, systematically and responsibly, to take the initiative and to assume personal responsibility.<br>5.1.3. To demonstrate creativity when solving professional and scientific research related problems. |

Annex 4 to the Descriptor of the Group of Study Fields of Computing

**Learning Outcomes of short studies in Studies of Computing**

| Group of learning outcomes | Field of study | Learning outcomes- skills |
|---|---|---|
| 1. Knowledge and its application | 1.1. All fields of study | 1.1.1. To explain the basic facts, concepts, theories and mathematical methods relevant to the operation of computers, computer hardware and software, its characteristic and practical application possibilities, and computer communication.<br>1.1.2. To explain the principles of algorithm construction, the specification of technical and functional requirements, the structures and technologies of programming languages, the principles of human-computer interaction, and the typical stages of the software lifecycle.<br>1.1.3. To comply with ethical standards and regulatory legal requirements such as data protection, intellectual property law, occupational safety and others.<br>1.1.4. To apply knowledge from a group of studies in computing to develop solutions to specific professional problems. |
| | 1.2. Informatics engineering | 1.2.1. To explain the basic methods of creating computer and other specialised digital techniques, their construction and operating principles, and their application to specific tasks. |
| | 1.3. Information systems | 1.3.1. To explain the basic facts, concepts and theories related to information systems and their development and maintenance.<br>1.3.2. To Explain the principles of data and information storage, management, retrieval, extraction, and methods and technologies for the design, management, implementation and administration of databases and repositories. |
| | 1.4. Software engineering | 1.4.1. To explain the software specification, design, development, testing and documentation, as well as software engineering processes, models and techniques. |
| 2. Research skills | 2.1. All fields of study | 2.1.1. To collect data to solve a professional problem in a specific study field of the group of study fields of computing.<br>2.1.2. To use the data to solve a professional problem in a specific study field of a group of study fields of computing |
| 3. Special abilities | 3.1. Informatics engineering | 3.1.1. To apply relevant computer engineering methods to solve specific professional application problems.<br>3.1.2. To use software and hardware to develop new systems or improve existing systems according to a given specification.<br>3.1.3. To implement the installation, maintenance, development and documentation of computer systems. |

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| | 3.2. Information systems | 3.2.1. apply information systems development and maintenance techniques, environments and tools in typical information systems development projects.<br>3.2.2. To select appropriate methods, environments and tools for the development and maintenance of information systems at representative stages of the lifecycle.<br>3.2.3. To prepare the documentation needed to set up, install, develop, use and administer the information system.<br>3.2.4. To implement an information system to address the business problem in the subject area, taking into account functional and non-functional requirements. |
| | 3.3 Software engineering | 3.3.1. To apply software systems development and maintenance techniques, development, testing and documentation environments and tools to typical software application systems projects.<br>3.3.2. To select suitable tools for developing, testing and maintaining software systems.<br>3.3.3. To program and document computer programmes and data structures. |
| 4. Social skills | 4.1. All fields of study | 4.1.1. To interact with professionals and clients to solve professional problems.<br>4.1.2. To work individually and as part of a team, in accordance with the principles and rules of professional and ethical behaviour and social responsibility. |
| 5. Personal skills. | 5.1. All fields of study | 5.1.1. Self-learning for continuous personal and professional development.<br>5.1.2. To work independently and responsibly by planning and organising own activities and take responsibility for own performance. |