

Chart 1. Learning outcomes for *data engineering* in relation to discipline-specific learning outcomes (formal sciences) and to achieving engineering competence

Learning outcomes for <i>data engineering</i>		
Studies of first degree Education profile: general academic Job title achieved by graduates: engineer		
CODE	Upon successful completion of first degree studies in the field of <i>data engineering</i>, students:	Relation to discipline-specific learning outcomes (formal sciences) and to achieving engineering competence
KNOWLEDGE		
K_W01	know the significance of computational mathematics for contemporary science and technology, and for the development of an information society	X1A_W01
K_W02	know selected methods, theorems and concepts of mathematical logic, linear algebra, discrete mathematics, graph theory and geometry, and understand their application to engineering modeling	X1A_W01, X1A_W02, X1A_W03
K_W03	know selected methods, theorems and concepts of differential and integral calculus, ordinary differential equations, probability theory and statistics, and understand their application to problems of engineering modeling	X1A_W01, X1A_W02, X1A_W03
K_W04	know and understand basic examples showing how to use given mathematical concepts in order to solve problems of technical, economic and formal sciences	X1A_W03
K_W05	have knowledge of higher mathematics necessary to build and analyze simple mathematical models in technical sciences	X1A_W02, X1A_W03

K_W06	know selected mathematical software packages used for symbolic and numeric computations, and applied in modeling and simulation of dynamic systems and processes	X1A_W05, InzA_W02, InzA_W05
K_W07	know fundamentals of computational techniques and programming facilitating the work of an analyst and are aware of their limitations; demonstrate knowledge of process approach and object-oriented methods in engineering issues	X1A_W04, X1A_W05, InzA_W02
K_W08	know selected programming languages and fundamentals of object-oriented programming; demonstrate knowledge of basic data structures (tables, lists, trees, objects, graphs), their computer representations and operations performed on them	X1A_W01, X1A_W04
K_W09	are familiar with various information tools which facilitate data processing and analysis, and statistical conclusion	X1A_W04, X1A_W05, InzA_W02, InzA_W05
K_W10	know most important problems which can be solved algorithmically with the use of mathematical apparatus and information techniques	X1A_W01, X1A_W02
K_W11	know basic techniques of algorithm construction and analysis, understand basic limitations in solving algorithmic problems	X1A_W01, X1A_W04
K_W12	know basic notions relating to numerical issues, as well as selected techniques of constructing numerical algorithms	X1A_W01, X1A_W04
K_W13	know methods of information and database systems management	X1A_W01
K_W14	demonstrate basic knowledge of various information tools relating to designing and use of database and computer systems which facilitate decision making; have basic knowledge of the lifecycle of devices and information systems	X1A_W04, InzA_W01, InzA_W05

K_W15	have basic knowledge of network technologies, including computer network architecture, communication protocols, safety, and network applications architecture	X1A_W01, X1A_W05, InzA_W05
K_W16	have basic knowledge concerning social aspects of information technology; are aware of ethical, economic and legal issues connected with professions of an analyst, mathematician and computer scientist; are familiar with general principles of creating and developing forms of individual entrepreneurship; have basic knowledge concerning protection of intellectual property and patent law	X1A_W07, X1A_W08, X1A_W09, InzA_W03
K_W17	know principles of occupational health and safety related to working with computers and computer networks	X1A_W06, InzA_W03
K_W18	have basic knowledge of economics, work organization and management; have basic knowledge of information activities which facilitate small and middle-sized firms and businesses	InzA_W04
K_W19	have achieved English language proficiency equivalent to level B2 of European Framework of Reference for Languages and are familiar with specialist terminology from selected branches of mathematics	X1A_W01
SKILLS		
K_U01	are able to use mathematical knowledge in order to model simple engineering tasks	X1A_U01, InzA_U01, InzA_U02
K_U02	are able to properly formulate a problem in the language of mathematics and carry out an analysis necessary to choose appropriate software to solve it; are able to assess possibilities and limitations of such approach	X1A_U01, X1A_U04
K_U03	can effectively use mathematical software and information tools to solve typical problems of discrete and continuous mathematics, to simulate a solution, and to visualize and interpret achieved results	X1A_U01, X1A_U02, X1A_U03, X1A_U04,

		InzA_U01, InzA_U02
K_U04	are able to design algorithms solving typical problems of discrete and continuous mathematics by designing and selecting appropriate algorithmic techniques and data structures	X1A_U01, X1A_U04
K_U05	can analyze designed algorithms in terms of their correctness and computational complexity	X1A_U01
K_U06	are able to skillfully and effectively implement classical and designed by them algorithms of discrete and continuous mathematics using a mathematical package or a programming tool appropriate for the discussed problem; are able to present a solution in a clear, graphical form	X1A_U01, X1A_U04, InzA_U02
K_U07	are able to introduce necessary mathematical notions and objects (e.g. functions, matrices, relations, recursively defined sequences) and define their basic properties in order to solve an engineering problem	X1A_U01
K_U08	are able to analyze and solve selected engineering problems relating to linear algebra using typical mathematical packages and programming languages	X1A_U01, X1A_U04
K_U09	can solve, both numerically and analytically, sets of equations (linear and non-linear) as well as an initial problem for ordinary differential equations	X1A_U01, X1A_U04
K_U10	can use the concept of boundary to approximate and define numbers and functions, and can critically evaluate effects of numerical approximation of numbers and functions; can analyze convergence of methods and the speed of convergence to a solution	X1A_U01, X1A_U04
K_U11	use with understanding the concept of derivative and integral of one variable and multivariable function; can use the concepts to analyze functions, in optimization issues, as well as to find areas and volumes of figures; use selected mathematical packages and numerical methods to solve chosen problems of differential and integral calculus	X1A_U01, X1A_U04

K_U12	are able to create and analyze graphs of functions and/or available data using mathematical software	X1A_U01, X1A_U04, InzA_U01
K_U13	can use with understanding concepts of probability theory; can analyze a specified mathematical model of a random experiment and simulate it numerically	X1A_U01, X1A_U02, X1A_U03, X1A_U04, InzA_U01
K_U14	are able to reach a statistical conclusion using appropriate software	X1A_U01, X1A_U02, X1A_U03, X1A_U04, InzA_U01
K_U15	can solve combinatorial and graph problems, as well as problems of number theory using algorithmic methods	X1A_U01, X1A_U04
K_U16	can present issues of computational mathematics in a clear and commonly understood language	X1A_U06, X1A_U09
K_U17	are able to, in a clear manner, both in oral and written form, formulate definitions and theorems, and give examples of applications of mathematical concepts studied during the course	X1A_U06, X1A_U08, X1A_U09
K_U18	can communicate with engineer and scientific community, and with business environment in order to discuss topics concerning computational mathematics and its applications	X1A_U06
K_U19	demonstrate the ability to prepare overviews and written papers concerning applications of mathematics in selected engineering problems and issues	X1A_U05, X1A_U08
K_U20	are able to get information from literature, Internet and other reliable sources, process and interpret it, as well as reach conclusion and formulate opinions	X1A_U07, X1A_U08, X1A_U09
K_U21	are able to study on their own and in a group; recognize and consider economic aspect of a task; can organize work and develop a schedule to meet deadlines; can carry out financial and economic analyses of a project	X1A_U07, InzA_U04, InzA_U06

K_U22	have achieved English language proficiency in the language of mathematics equivalent to level B2 of European Framework of Reference for Languages	X1A_U08, X1A_U09, X1A_U10
K_U23	are able to assess the usefulness of mathematical and information methods and tools, select and apply adequate methods and tools to complex engineering problems	X1A_U01, InzA_U05, InzA_U06, InzA_U07
K_U24	demonstrate skills to use existing software for operating systems, databases and computer networks effectively	X1A_U04
K_U25	are able to, in accordance with a given specification, analyze, design, and build a simple database system using appropriately selected methods, techniques and tools	X1A_U01, X1A_U04, InzA_U06, InzA_U07, InzA_U08
K_U26	can ensure the security of data and computer networks	InzA_U03, InzA_U08
K_U27	can use analytical, numerical, and experimental methods to formulate and solve engineering tasks; recognize their non-technical and system aspects	InzA_U02, InzA_U03
K_U28	solve basic problems relating to information processing; select mathematical methods and information tools adequate for specified types of tasks	InzA_U05, InzA_U06
SOCIAL COMPETENCE		
K_K01	understand the need to improve their qualifications by extending their knowledge and practical skills	X1A_K01, X1A_K05
K_K02	take an active part in dialogues in order to clarify, deepen and/or extend their understanding of the topic under discussion; can work in a team, taking on different roles	X1A_K02
K_K03	are able to set priorities in order to accomplish a task set by themselves or by others; understand the need of systematic work on long term projects	X1A_K02, X1A_K03

K_K04	understand and appreciate the significance of intellectual honesty, both in their own and in other people's activities; demonstrate ethical behaviour	X1A_K04
K_K05	recognize the ethical, legal and social aspects of computerization, and in their professional activities act according to the principles relating to those aspects	X1A_K04, X1A_K06
K_K06	are able to think and act in creative and enterprising ways	X1A_K07, InzA_K02
K_K07	understand and are aware of the importance of technical and non-technical aspects and results of engineer's activities and consequent responsibility for decisions	InzA_K01

Chart 2. Relation of discipline-specific learning outcomes for formal sciences and of achieving engineering competence to learning outcomes for *data engineering*

CODE	First degree graduates with qualifications relating to formal sciences and achieving engineering competence	Relation to learning outcomes for <i>data engineering</i>
KNOWLEDGE		
X1A_W01	have general knowledge of basic concepts, principles and theories typical for academic disciplines and research fields relating to the course content	K_W01, K_W02, K_W03, K_W08, K_W10, K_W11, K_W15, K_W19
X1A_W02	know the techniques of higher mathematics necessary for quantitative description, understanding and modeling problems with average level of complexity	K_W02, K_W03, K_W05, K_W10
X1A_W03	understand and are able to explain descriptions of regularities, phenomena and processes which use the language of mathematics; can independently reconstruct basic theorems and laws	K_W04, K_W05

X1A_W04	know basic computational methods used to solve problems typical for academic disciplines and research fields relating to the course content; know examples of practical implementation of such methods with the use of adequate information tools; know fundamentals of programming and software engineering	K_W07, K_W08, K_W09, K_W11, K_W12, K_W14
X1A_W05	know basic aspects of how scientific apparatus, used in research relating to the course content, is built and how it works	K_W06, K_W07, K_W09, K_W15
X1A_W06	know basic principles of occupational health and safety	K_W17
X1A_W07	have basic knowledge of the law and ethics related to scientific research and teaching	K_W16
X1A_W08	know and understand basic concepts concerning industrial property and copyright law; know how to use patent information resources	K_W16
X1A_W09	know general principles of creating and developing forms of individual entrepreneurship which uses knowledge associated with academic disciplines and research fields relating to the course content	K_W16
InzA_W01	have basic knowledge of the lifecycle of equipment, objects and technical systems	K_W14
InzA_W02	know basic methods, techniques, tools and materials used while solving complex engineering tasks relating to their field of study	K_W06, K_W07, K_W09
InzA_W03	have basic knowledge necessary to understand social, economic, legal and other non-technical aspects of engineering activities	K_W17
InzA_W04	have basic knowledge concerning management, including quality management and business activity	K_W18

InzA_W05	know engineering technologies relating to their field of study	K_W06, K_W09, K_W14, K_W15
SKILLS		
X1A_U01	are able to analyze problems and find solutions basing on previously studied theorems and methods	K_U01, K_U02, K_U03, K_U04, K_U05, K_U06, K_U07, K_U08, K_U09, K_U10, K_U11, K_U12, K_U13, K_U14, K_U15, K_U23, K_U25, K_U27
X1A_U02	are able to carry out quantitative analyses and, basing on them, formulate qualitative conclusions	K_U03, K_U13, K_U14
X1A_U03	are able to plan and do experimental research or observations, and analyze achieved results	K_U03, K_U13, K_U14
X1A_U04	can use numerical methods to solve mathematical problems; demonstrate the ability to use basic software packages and chosen programming languages	K_U02, K_U03, K_U04, K_U06, K_U08, K_U09, K_U10, K_U11, K_U12, K_U13, K_U14, K_U15, K_U24, K_U25
X1A_U05	can prepare a paper presenting a problem within academic disciplines and research fields relating to the course content, as well as methods of solving it	K_U19
X1A_U06	are able to present in a clear manner facts within academic disciplines and research fields relating to the course content	K_U16, K_U17, K_U18
X1A_U07	are able to self-learn effectively	K_U20, K_U21
X1A_U08	using basic theoretical approaches and other sources, are able to prepare written works concerning specific issues, both in Polish and a foreign language considered to be basic for disciplines and research fields relating to the course content	K_U17, K_U19, K_U20, K_U22

X1A_U09	using basic theoretical approaches and other sources, are able to prepare an oral presentation concerning specific issues, both in Polish and a foreign language	K_U16, K_U17, K_U20, K_U22
X1A_U10	have achieved discipline-specific English language proficiency equivalent to level B2 of European Framework of Reference for Languages	K_U22
InzA_U01	can plan and carry out experiments, including computer measurements and simulations, can interpret achieved results and draw conclusions	K_U01, K_U03, K_U12, K_U13, K_U14
InzA_U02	can use analytical, simulation, and experimental methods to formulate and solve engineering problems	K_U01, K_U03, K_U06, K_U27
InzA_U03	can – when formulating and solving engineering tasks – notice their non-technical and system aspects	K_U26, K_U27
InzA_U04	can carry out an initial economic analysis of engineering tasks they have undertaken	K_U21
InzA_U05	are able to carry out a critical analysis of the way of functioning and can assess - especially in relation to their field of study – existing technical solutions, in particular devices, objects, systems, processes and services	K_U23, K_U28
InzA_U06	can identify and formulate a specification of simple practical engineering tasks typical for their field of study	K_U21, K_U23, K_U25, K_U28
InzA_U07	can assess the usefulness of routine methods and tools used to solve a simple practical engineering problem typical for their field of study, can choose and apply adequate method and tools	K_U23, K_U25
InzA_U08	using appropriate methods, techniques and tools, can – according to a given specification – design and build a simple device, object, system or process typical for their field of study	K_U25, K_U26

SOCIAL COMPETENCE		
X1A_K01	graduates understand the need for lifelong education	K_K01
X1A_K02	can cooperate and work in a team, taking on different roles	K_K02, K_K03
X1A_K03	can set priorities to accomplish a task set by themselves or by others	K_K03
X1A_K04	identifies and solves problems associated with professional activities	K_K04, K_K05
X1A_K05	understand the need for improving professional and personal competence	K_K01
X1A_K06	understand social aspects of practical application of acquired knowledge and skills and are aware of the consequent responsibility	K_K05
X1A_K07	are able to think and act in enterprising ways	K_K06
InzA_K01	are aware of the importance and understand non-technical aspects and results of engineer's activities, including influence on the environment, and the consequent responsibility for decisions	K_K07
InzA_K02	are able to think and act in enterprising ways	K_K06