Master's, Doctoral, and Post-doctoral Track Program: Computer & Data Science

1. Open Doors winner's skill set

Winning the Open Doors competition requires a comprehensive set of competencies in computer and data science, including:

- a solid understanding of computer science fundamentals, including discrete and applied mathematics;
- the ability to evaluate algorithmic complexity and select appropriate data structures;
- proficiency in computer architecture, networking, and operating systems; familiarity with information security regulations; mastery of cryptographic techniques; and competence with at least one modern programming language, an integrated development environment (IDE), and version control systems;
- fluency in technologies related to computer and data science, including machine learning, artificial intelligence, data analysis, software verification methods, and project management.

The winner is expected to demonstrate a solid command of the following practical skills:

- software Development: algorithm and program design, coding, debugging, testing, and optimization; application of information-theoretic models;
- technical Proficiency: integration and use of libraries, SDKs, and ML frameworks; configuration of encryption protocols and deployment of cybersecurity tools; OS administration, software deployment, and network-service configuration;
- adaptability: assessment of IT market trends; rapid mastery of emerging tools to maintain system efficiency and security.

2. List of degree programs covered by the subject area

2.1. List of doctoral degree programs

1 2 1 Artificial intelligence and machine learning
1 2 4 Cybersecurity
2 3 1 System analysis, management and information processing, statistics
2 3 2 Computing systems and their elements
2 3 5 Math- and software for computer systems, complexes and computer networks
2 2 15 Telecommunication systems, networks and equipment

2.2. List of master's degree programs

01.04.02 Applied Mathematics and Informatics
02.04.02 Fundamentals of Computer Science and Information Technology
09.04.01 Informatics and Computer Engineering
09.04.02 Information Systems and Technology
09.04.03 Applied informatics
09.04.04 Software Engineering
11.04.02 Infocommunication Technologies and Communication Systems

3.Content

Field of science 1. Applied Mathematics

1. Big-O Notation. Asymptotic complexity (O, Ω, Θ), worst-case and average-case analysis.
2. Linear space: definition of a space, dimension. Matrix rank. Matrix determinant. Inverse matrix. Eigenvalues and eigenvectors.
3. Modular arithmetic. Fermat's Little Theorem. Finite residue fields: definition of a finite field, performing computations in a residue field. Euclidean algorithm. Linear representation of GCD.

4. Numeral systems. Converting numbers between different numeral systems.
5. Boolean algebra. Standard Boolean operations: conjunction, disjunction, implication, equivalence, exclusive OR, NAND, NOR. Constructing formulas for Boolean functions: DNF, CNF, simplification using De Morgan's laws, distributive rules, absorption.
6. Functional element circuits. Complexity and depth: definition, calculation for specific circuits. Constructing a circuit for a given Boolean function based on a formula.
7. Inductive (recursive) definitions. Proofs by structural induction.
8. Integer algorithms: working with arbitrary-precision numbers. Euclidean algorithm and its applications.
9. Probability definition. Elementary properties: probability addition theorem, probability multiplication theorem.
10. Probability distributions: uniform, binomial, geometric, Poisson, normal.
11. Law of total probability.
12. Bayes' theorem.
13. Basic combinatorial numbers: counts of permutations, combinations. Solving counting problems.
14. Growth rates of combinatorial numbers: asymptotic estimation of expressions with combinatorial numbers.
15. Generating combinations and permutations.
16. Inclusion–exclusion principle.
17. Graphs: undirected, directed, bipartite, complete (cliques). Subgraphs: general definition, induced subgraph, spanning subgraph. Graph distances. Breadth-first search and depth-first search.
18. Trees. Minimum spanning tree problem.
19. Planar graphs. Euler's formula for planar graphs.
20. Finite automata: definitions, examples of recognized languages. Nondeterministic finite automata.
21. Regular expressions. Constructing an automaton recognizing a language described by a regular expression. POSIX Extended regular expression syntax standard.

Field of science 2. Software Engineering

1. Software requirements
2. Software design
3. Software lifecycle
4. Error and interrupt handling
5. Software security
6. Design patterns
7. User interface design
8. Software complexity
9. Software construction standards
10. Software reuse
11. Executable models
12. Object-oriented programming fundamentals
13. Software testing
14. Software maintenance
15. Software reengineering
16. Software configuration management
17. Software build

18. Product management
19. Software development management
20. Software quality management
21. Software risk assessment
22. Software metrics
23. Software prototyping
24. Software system modeling, UML language

Field of science 3. Informatics and Information Systems

1. Concept of information: General characteristics of information collection, transmission, processing, and storage; information measurement. Units of information measurement. Information and entropy.
2. Concept of information systems and information technologies.
3. Hardware and software tools of information technologies.
4. Concept of a system: Systems in engineering, economics, and living nature. Types of systems. Control object and control system. Information. Feedback. Subject of technical cybernetics and information theory.
5. Modeling as a scientific method of cybernetics: Types of models. Models of technical, biological, and socio-economic systems. Concept of a "black box". Identification problem. Model adequacy.
6. Pragmatic, semantic, and syntactic aspects of information.
7. Reliability of the hardware-software complex of an information system.

Field of science 4. Hardware Architecture

1. Operating systems and computing resource management: OS classification, process/thread scheduling, synchronization mechanisms, and interprocess communication.
2. Parallel computing architectures: Multi-core CPUs, GPGPU, clusters, and categories of modern parallel computing systems.
3. Hardware acceleration: GPU, FPGA, ASIC, and specialized co-processors.
4. Memory hierarchy: Cache levels, RAM, virtual memory, addressing, and management mechanisms.
5. Storage systems and data protection: RAID arrays, NAS/SAN, and cloud storage solutions.
6. I/O subsystems and peripheral interfaces: Bus architectures, DMA controllers, and device connection standards.
7. Embedded and System-on-Chip (SoC) platforms: Microcontrollers, single-board computers, and their architectural specifics.
8. Software-defined architecture and virtualization: SDA, hardware-assisted virtualization, and cloud containerization.
9. Network models and architectures: ISO/OSI, TCP/IP stack, IP addressing, and routing.
10. Wired networks and backbone communications: Ethernet, MPLS, core networks, traffic management, and QoS.
11. Optical and satellite communication systems: FTTx principles and satellite link architectures.
12. Wireless and mobile networks: Wi-Fi, Bluetooth, NFC; 3G/4G/5G standards and their evolution.
13. Network virtualization and software-defined communications: SDN, NFV, and their role in flexible infrastructure management.
14. VoIP and multimedia over IP: Protocols, standards, and QoS for voice/video.

15. IoT and industrial networks: IoT architecture, SCADA, and industrial automation protocols.
16. Network security and lifecycle management: Cryptographic protection, monitoring, diagnostics, and management tools.

Field of science 5. Computer Science and Artificial Intelligence

1. Machine Learning as a branch of Artificial Intelligence: Definition and fundamental concepts.
2. Main types of Machine Learning tasks: Classification, regression, clustering, association rule mining, anomaly detection.
3. Knowledge Discovery Process: Key stages of Data Mining. Data Science.
4. Classification algorithms: Naive Bayes, C4.5, CART, BackPropagation, SVM, etc.
5. Model evaluation: Performance metrics for classification and regression (F1-score, AUC-ROC).
6. Clustering algorithms: Hierarchical, k-Means, EM, DBSCAN, SOM, etc.
7. Association rule mining algorithms: Apriori, FP-Growth.
8. Ensemble methods: Bagging, Boosting, Stacking. Random Forest algorithm.
9. Deep Learning: Definition. Key differences from traditional Machine Learning.
10. Fuzzy Set Theory and Fuzzy Logic: Linguistic variables. Fuzzy inference. Mamdani algorithm.

Field of science 6. Interdisciplinary Applications of Computer Science

1. Decision Support Systems (DSS): Objectives, architectures, and development methodologies.
2. Data Warehousing: Purpose, multi-tier architecture, virtual/physical data marts, ETL processes, and data cleansing.
3. Information Security: Objects, subjects, and influencing factors.
4. Information Security Threats and Modeling Methods.
5. Information Risk Management: Identification, assessment, criteria, and scales.
6. Information Security Management Systems (ISMS): Principles and lifecycle.
7. Intrusion Detection/Prevention Systems (IDS/IPS): Classes, algorithms, and applications.
8. Access Control Models and Mechanisms: MAC, DAC, RBAC, ABAC.
9. Symmetric Encryption: Block ciphers, modes of operation, modern standards.
10. Identification, Authentication, and Authorization: Methods and protocols.
11. Steganography: Purpose, applications, and methods for embedding hidden data in executable files.
12. Symmetric Encryption Systems: Block ciphers, operational modes, modern standards and protocols.
13. Public-Key Cryptosystems: Design principles, modern standards and protocols.
14. Public Key Infrastructure (PKI): Certification authorities and digital certificates.
15. Computer Graphics: Rendering pipeline and rasterization (stages, buffering, Z-test).
16. Computer Graphics: Lighting and shading models (Lambert, Phong, Blinn-Phong).
17. Computer Graphics: Geometric scene modeling (polygonal meshes, splines, LOD).
18. Computer Graphics: Realistic animation and physical simulation (skeletal models, cloth, fluids).
19. Augmented/Mixed Reality: SLAM algorithms, virtual-real composition in HMDs.
20. Geostatistics and Spatial Modeling in GIS: Classical interpolation methods (IDW, Kriging, splines).

4.Preparation materials

4.1 Recommended reading

Field of science 1. Applied Mathematics

Reading list in English
Durrett R. Probability: Theory and Examples (Cambridge Series in Statistical and Probabilistic Mathematics Book 49) 5th Edition, 2019. 490 p. URL://https://services.math.duke.edu/~rtd/PTE/PTE5_011119.pdf
Heinold B. A Simple Introduction to Graph Theory, 2024. 135 p. URL://https://brianheinold.net/graph_theory/graph_theory_book.html
Mitchel T. Keller, William T. Trotter. Applied Combinatorics, 2017. 393 p. URL://https://www.infobooks.org/pdfview/17733-applied-combinatorics-mitchel-t-keller-william-t-trotter/

Field of science 2. Software Engineering

Reading list in English
Bass L., Clements P., Kazman R. Software Architecture in Practice, 3rd ed., Addison-Wesley Professional, 2021. URL://https://www.oreilly.com/library/view/software-architecture-in/9780136885979/
Bourque P., Fairley R.E. Guide to the Software Engineering Body of Knowledge (SWEBOK(R)): Version 3.0. IEEE Computer Society URL://https://www.computer.org/education/bodies-of-knowledge/software-engineering
ISO/IEC/IEEE 24765:2017 Systems and Software Engineering—Vocabulary, ISO/ IEC/IEEE, 2017. URL://https://www.iso.org/standard/71952.html

Field of science 3. Informatics and Information Systems

Reading list in English
Hopcroft J.E., Motwani R., Ullman J.D. Introduction to automata theory, languages, and computation. 2001. 535 p. URL://https://www-2.dc.uba.ar/staff/becher/Hopcroft-Motwani-Ullman-2001.pdf
Rainer R.K., Prince B., Cegielski C. G. Introduction to Information Systems. John Wiley & Sons Singapore Pte. Limited, 2015. 531 p. URL://https://humdiana.files.wordpress.com/2018/03/introduction-to-information-system-edisi-5-tahun-2014.pdf
Tanenbaum A.S. et al. Computer networks. Prentice-Hall international editions, 1996. 674 p. URL://https://theswissbay.ch/pdf/Gentoomen%20Library/Networking/Prentice%20Hall%20-%20Computer%20Networks%20Tanenbaum%204ed.pdf

Field of science 4. Hardware Architecture

Reading list in English
Harris D., Harris S. Digital Design and Computer Architecture. Publisher: Morgan Kaufmann, 2012. 561 p. URL://https://www.r-5.org/files/books/computers/hw-layers/hardware/digital-desigh/David_Harris_Sarah_Harris-Digital_Design_and_Computer_Architecture-EN.pdf
Patterson David A., Hennessy John L. Computer Organization and Design RISC-V Edition. Elsevier Science. 1665 p. URL://http://home.ustc.edu.cn/~louwenqi/reference_books_tools/Computer%20Organization%20and%20Design%20RISC-V%20edition.pdf
Tanenbaum A., Austin T. Structured Computer Organization. Publisher: Pearson, 2012. 801 p.

URL://https://csc-knu.github.io/sys-prog/books/Andrew%20S.%20Tanenbaum%20-%20Structured%20Computer%20Organization.pdf

Field of science 5. Computer Science and Artificial Intelligence

Reading list in English
Alpaydin E. Introduction to Machine Learning. London: The MIT Press, 2010. 579 p. URL://https://kkpatel7.files.wordpress.com/2015/04/alppaydin_machinelearning_2010.pdf
Goodfellow I., Bengio Y., Courville A. Deep Learning. MIT Press, 2016. URL://https://www.deeplearningbook.org/
Russell S., Norvig P. Artificial Intelligence: A Modern Approach. Publisher: Pearson, 2021, 1133 p. URL://http://lib.ysu.am/disciplines_bk/efdd4d1d4c2087fe1cbe03d9ced67f34.pdf

Field of science 6. Interdisciplinary Applications of Computer Science

Reading list in English
Eagle C., Nance V. The Ghidra Book: The Definitive Guide. No Starch Press, 2020. 608 p. URL://https://www.amazon.com/Ghidra-Book-Definitive-Guide-ebook/dp/B0852N9Y4Q
Ferguson N., Schneier B., Kohno T. Cryptography Engineering: Design Principles and Practical Applications 1st Edition, Wiley, 2011. 386 p. URL://https://www.schneier.com/wp-content/uploads/2015/12/fortuna.pdf
Isaaks E.H., Srivastava R.M. An introduction to applied geostatistics. Oxford university press, Oxford, 1989. 577 p. URL://https://www.geokniga.org/bookfiles/geokniga-anintroductiontoappliedgeostatistics.pdf
Marschner S., Shirley P. Fundamentals of Computer Graphics. Publisher: A K Peters/CRC Press, 2015. 737 p. URL://http://repo.darmajaya.ac.id/5422/1/Fundamentals%20of%20Computer%20Graphics%2C%20Fourth%20Edition%20%28%20PDFDrive%20%29.pdf

4.2 Recommended online courses

Field of science 1. Applied Mathematics

Online courses in English	**Link**	**Course description**
Mathematical Thinking in Computer Science	https://www.coursera.org/learn/what-is-a-proof	Mathematical thinking is fundamental to various domains within computer science, including algorithms, bioinformatics, and machine learning. This course introduces essential tools of discrete mathematics—such as induction, recursion, logic, and invariants—and applies them to core programming questions related to the existence of solutions, their optimality, and the fulfillment of given constraints. Emphasizing a hands-on, discovery-based approach, the course engages students in solving interactive puzzles that foster intuitive understanding and independent formulation of key mathematical concepts.

Combinatorics and Probability	https://www.coursera.org/learn/combinatorics	Counting is a fundamental task in mathematics, often requiring more efficient methods than tallying items one by one. Combinatorics is a branch of mathematics concerned with counting, arranging, and analyzing discrete structures. It studies how objects can be combined, permuted, or selected according to specific rules, often focusing on finite or countable sets. This online course covers standard combinatorial settings and their applications, focusing on real-life and algorithmic problems, recursive counting techniques, and the basics of probability theory, essential for such fields as statistics and machine learning.
Single Variable Calculus	https://www.coursera.org/learn/discrete-calculus	This course covers single-variable Calculus with a focus on conceptual understanding and applications, ideal for engineering, physical, and social science students. Key features include early introduction of Taylor series, synthesis of discrete and continuous Calculus, emphasis on concepts over computations, and a clear, unified approach.

Field of science 2. Software Engineering

Online courses in English	**Link**	**Course description**
Software Development Lifecycle	https://www.coursera.org/specializations/software-development-lifecycle	This course is designed for both newcomers to software engineering and those seeking deeper insights into software development practices. By the end of the course, learners will be able to build secure software using SDLC methodologies, analyze and improve a team's SDLC approach, and compare different methodologies based on various constraints. Applied projects will involve fictional case studies where learners will make decisions on methodologies, practices, and processes, including creating story maps and value stream maps.
IBM DevOps and Software Engineering Professional Certificate	https://www.coursera.org/professional-certificates/devops-and-software-engineering	This course equips students with fundamental DevOps practices, tools, and technologies, preparing them for entry-level roles in software engineering. It provides hands-on experience with Python, Linux shell scripting, GitHub project management, Docker, Kubernetes, continuous integration and continuous deployment (CI/CD), and cloud computing technologies. Instruction is delivered by IBM experts, enabling students to build a portfolio of projects that demonstrate their proficiency in DevOps.
IBM Full Stack Software	https://www.coursera.org/profession	This course covers full stack development, cloud native technologies, and generative AI tools,

Developer Professional	al-certificates/ibm-full-stack-cloud-developer	equipping you to build, deploy, test, and manage applications using technologies like Node.js, React, Docker, Kubernetes, and more. The course enables students to create a portfolio of projects, including HTML pages, AI programs, containerized apps, and cloud-native solutions.

Field of science 3. Informatics and Information Systems

Online courses in English	**Link**	**Course description**
Information Systems	https://www.coursera.org/specializations/information-systems	This four-course series provides a comprehensive introduction to Information Systems Management. It begins with an examination of how information systems support and align with business strategies, including an economic analysis of their role and value. The second course focuses on modelling techniques for information systems to support effective system design and development. The third course addresses the capabilities of enterprise systems and the managerial considerations involved in their selection and implementation. The final course explores IT infrastructure choices, associated trade-offs, and the importance of managing technological change. Through applied learning projects, students will tackle real-world business challenges by conceptualising IT solutions, defining system specifications, and evaluating or developing system implementations.
Introduction to Computer Science and Programming	https://www.coursera.org/specializations/introduction-computer-science-programming	This course covers basic computing principles and mathematical foundations crucial for computer science. Students will learn how computers work, develop introductory programming skills for interactive and graphical applications, and gain numerical mathematics tools for problem-solving and modeling. Applied Learning Projects include solving mathematical puzzles, using interactive sleuth applications, and applying computer science concepts to real-world problems, making the learning process engaging and practical.
How to Code: Simple Data	https://www.edx.org/course/how-to-code-simple-data	This course provides a structured introduction to programming, focusing on universal design principles rather than a specific programming language. It aims to strengthen students' ability to write clear, reliable, and maintainable code in any language. Core topics include the systematic design of programs that manipulate numbers, strings, images, and lists. Students will learn to formulate precise specifications, construct consistently organized code, and integrate testing into the

		development cycle. The course culminates in the design and implementation of a simple interactive game, allowing students to apply the concepts and techniques acquired.

Field of science 4. Hardware Architecture

Online courses in English	Link	Course description
Computer Architecture	https://www.coursera.org/learn/comparch	This course introduces the fundamental concepts of computer architecture, focusing on the design and organization of computer systems. It covers key topics such as instruction set architecture, processor design, memory hierarchy, and input/output systems. Both theoretical foundations and practical applications are addressed, with real-world examples illustrating how computer architecture influences overall system performance.
Introduction to Hardware and Operating Systems	https://www.coursera.org/learn/introduction-to-hardware-and-operating-systems	The course covers essential hardware and operating system knowledge. Students will learn about computer components, interfaces, and peripherals, as well as IT tasks like workstation setup and troubleshooting. The course includes interactive exercises and hands-on labs, culminating in a final project to apply your skills.
Computer and Peripheral Hardware	https://www.coursera.org/learn/illinois-tech-computer-and-peripheral-hardware	This course provides an introduction to computer hardware components and peripherals, including cables, memory, storage devices, motherboards, central processing units (CPUs), and multifunction devices. It covers the identification and installation of various hardware elements, the configuration of essential system components, and the fundamental electronic principles related to power supplies and device settings.

Field of science 5. Computer Science and Artificial Intelligence

Online courses in English	Link	Course description
Deep Learning in Computer Vision	https://learnonline.hse.ru/course/view.php?id=6148	This course introduces students to the basics of computer vision and modern deep learning models, covering image and video recognition, object detection, motion estimation, etc. The course project focuses on building a face recognition and manipulation system, illustrating the internal mechanics of this widely recognized technology.

Supervised Machine Learning: Regression and Classification	https://www.coursera.org/learn/machine-learning	The first course of this Machine Learning Specialization introduces the fundamentals of building and training machine learning models using Python, with a focus on libraries such as NumPy and scikit-learn. Emphasis is placed on linear and logistic regression for prediction and classification tasks. Designed for beginners, the course offers a comprehensive overview of supervised and unsupervised learning, along with industry best practices. As part of a three-course series, it equips learners with essential theoretical knowledge and practical skills to address real-world AI challenges and pursue a career in machine learning.
Deep Learning	https://www.coursera.org/specializations/deep-learning	The Deep Learning Specialization is a foundational program designed to provide essential skills for advancing in the field of artificial intelligence. It covers the construction and training of neural network architectures, including Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transformers. Learners gain proficiency in techniques such as Dropout and Batch Normalization, using Python and TensorFlow to implement real-world applications such as speech recognition, image analysis, and conversational AI. The program also offers expert guidance on career development. Upon completion, students will be equipped to optimize neural networks and apply advanced deep learning methods to complex tasks.

Field of science 6. Interdisciplinary Applications of Computer Science

Online courses in English	**Link**	**Course description**
IT Security: Defense against the digital dark arts	https://www.coursera.org/learn/it-security	This course covers fundamental IT security concepts and tools, including threats, attacks, and data encryption. Students will learn about authentication, authorization, and accounting systems, as well as network security solutions and how to create a multi-layered security architecture. By the end of the course, students will be able to recommend risk reduction strategies and implement a security culture within an organization.
UCSanDiegoX: Computer Graphics	https://www.edx.org/learn/computer-graphics/the-university-of-california-san-	The course focuses on three core competencies: generating 3D computer graphics, developing real-time scene viewers, and producing photorealistic imagery through raytracing techniques. The course introduces methodological tools essential for mastering the mathematical foundations of virtual

	diego-computer-graphics	camera placement through practical exercises with 3D objects. The curriculum then progresses to real-time graphics programming using industry-standard tools like OpenGL and GLSL, enabling students to create interactive 3D environments. The course culminates with advanced raytracing methods for creating images with realistic lighting, reflections, and shadows.
Learn Unity Shaders from Scratch	https://www.udemy.com/course/learn-unity-shaders-from-scratch/	This course offers comprehensive training in Unity shader development, incorporating the latest Unity 6 technologies, including Universal Render Pipeline (URP) and Shader Graph. The course delivers authoritative instruction in HLSL shading language and visual shader creation techniques. Designed for both programmers and artists, the course begins with fundamental HLSL concepts, assuming no prior C-language knowledge, and progresses systematically to advanced shader effects.
Geographic Information Systems (GIS)	https://www.coursera.org/specializations/gis	This course provides comprehensive training in Geographic Information Systems (GIS), developed in collaboration with Esri, the industry-leading ArcGIS platform developer. The program equips professionals with essential geospatial analysis and cartographic visualization skills applicable across diverse sectors, including agriculture, urban planning, and public health.
Fundamentals of Earth Remote Sensing and Geographic Information Systems	https://stepik.org/course/170081	This course provides fundamental knowledge of Earth Remote Sensing (ERS) and Geographic Information Systems (GIS), covering their core principles and modern applications. The program consists of six comprehensive modules addressing The course provides a comprehensive introduction to Earth Remote Sensing (ERS) technologies, satellite missions, Geographic Information Systems (GIS), spatial data analysis, and their practical applications across various domains. Key learning outcomes include: understanding the rationale for space-based Earth observation; evaluating remote sensing technologies' advantages and limitations; comprehending satellite imagery production processes; assessing GIS roles, components, and operational constraints; mastering spatial data characteristics and analytical methods. The course is designed for master's degree students seeking professional competencies in geospatial technologies and their practical applications.