Kazakh national research technical University named after K. I. Satpayev
Institute of Cybernetics and information technologies
Scientific and educational center of mathematics and Cybernetics

CURRICULUM PROGRAM

"CYBERNETICS AND ARTIFICIAL INTELLIGENCE"

Doctor of philosophy PhD in the educational program
"8D06104 - Cybernetics and artificial intelligence "

Almaty 2020

Программа составлена и подписана сторонами:

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Утверждено на заседании Учебно-методического совета Казахского национального исследовательского технического университета имени К.И. Сатпаева. Протокол №3 от 19.12.2018 г.

Approved at the Session of Educational and Methodological Board of NJSC «K.I. Satbayev Kazakh National Research Technical University».
Protocol №3 of 19.12.2018.

Qualification:
The 8D level of the technologies of information and communication, «8D06»

Professional competence:

- ability to apply the perspective methods of study and using solutions of professional tasks, which based on the world tendencies of the development of mathematics, computer engineering and information technologies;
- ability to develop conceptual and theoretical models of solving scientific problems and applied tasks;
- ability to plan scientific and research activity, to analyze risks and to manage projects.

SHORT DESCRIPTION OF THE PROGRAM

The educational program belongs to engineering specialization.

It is aimed at providing basis and professional courses with due competence to students.

The tasks and content of the program are described in Section 7 of the document: «Description of the courses».

The specialization is created with the focus on training competitive professionals in computer science and information technologies, which will possess the valuable knowledge in such future technologies as artificial intelligence and hence will be distinguished on the international IT market.

Students will study the main methods of artificial intelligence on simple handy problems and get the mathematical foundation of machine learning and artificial intelligence. The main idea of this program consists in modelling the intellectual activity by means of computers. Completing the program, students will have the knowledge of working machine learning algorithms and will be able to implement these skills in solution of various (theoretical or applied) problems. After successful completion of the program the students will be graduated the «bachelor» degree.

The education process presumes an active research work, participation in research projects supervised by leading specialists in priority scientific areas, and internship in foreign high-profile scientific and educational institutions. Some classes will get lectures by invited professors from Germany, France, Slovenia, etc.

For students to acquire competitive skills, the program includes innovative courses that cover all necessary areas from Mathematics, Data Science, Data Engineering and Quantitative Analysis (in Python and R languages).

The «Cybernetics and artificial intelligence» program includes such innovative disciplines as:

- Parallel computing;
- Artificial neural networks and their applications;
- Machine learning;
- Quantum programming for data analysis.

PhD students of the program will acquire such skills as:

- ability to formulate and build models
- ability to create complicated motion effects to visualize the results of their own projects
- ability to make effective decisions for project management

The graduated student must

be acquainted with:

- the object under study
- the modern methods and programming tools for investigating and modelling various processes

know:

- theoretical and practical foundations for mathematical modelling of physical, medical, chemical and biological processes
- high level programming languages, visual programming tools, and modelling languages
- computers, system administration, computer networks, operation systems, applied programs

be able to:
- analyze the object under study
- create a mathematical model
- apply mathematical tools for problems' solution
- optimally utilize computers
- develop and create data bases
- write computer programs

The graduates of the program will have the knowledge and skills to realize themselves in various professional activities like:
- scientific and educational areas
- mathematical and computer modelling, and artificial intelligence
- computer programming
- research, technical experiments and analyses, experimental developments of natural sciences and engineering
- state management
- business area as a top management
- research institutes

The students have the opportunity to do their internship and work in all banks of Kazakhstan, KazMunaiGaz and other oil and gas companies, Institute of mathematics and mathematical modelling, Institute of information and computer technologies, "National scientific laboratory of information and space technologies" and, also, in the School of Mathematics and cybernetics of Satbayev University.

Furthermore, this program provides the exchange program in liaison with foreign universities such as Lublin University of Technology (Poland), the University of Bielsko-Biala (Poland), University of L'Aquila (Italy), New York University, Girne American University (island of Cyprus), the University of Windsor (Canada), etc.

PASSPORT OF THE EDUCATIONAL PROGRAM

The scope and content of the program

The curriculum program is oriented on the fundamental educational, methodological and research preparation.

The content of the curriculum program is established by the university.

The main indicator of an accomplishment of the educational program is the presence of enough academic hours, which cannot be more than 180.

The PhD curriculum program focuses on both directions:

1. scientifically pedagogical direction (at least three years)
2. profile direction (at least three years)

The content of the curriculum program consists of:
1. the theoretical learning , including the based and special disciplines

2. internships and scientific study placement
3. scientifically research work
4. final attestation

The content of the "Cybernetics and Artificial Intelligence" program:

Educational program tasks:

1. The purposes of the curriculum program

The curriculum programme involves issues about fundamentals of the artificial intelligence system, features of its organization, functionality, life cycles and directions. Moreover, the programme helps to students to develop their competences in the project processes and professional activity in the contemporary intellectual systems.

Therefore, the curriculum programme focuses on the preparation of highly qualified specialists, who is capable to develop both computer and mathematical models for different applications according on the development of digital economy. The program has a practice-oriented base using the modern laboratory "Sigma LABS" at the School of mathematics and cybernetics.

Nowadays, the artificial intelligence modelling has two main approaches:

1. Machine intelligence, based on the strong task of the result of functioning;
2. Artificial intelligence, focusing on the modeling of the internal structure of the system.

The approaches division relates with the existence of two points of view on the question of how to build artificial intelligence systems.

The one side represents, that the most important fact is the result. It means, that the main idea focuses on the concurrence of artificial and natural intelligent systems, but not on the process of formulation of behavior through the internal mechanisms.

Another point of view is the consideration that the basis of the construction of artificial intelligence involves mechanisms of natural thinking and the analysis of data, which characterize the rational human behavior. Thus, this process is realized by the modeling using the technical principles and the specifics of the functionality of biological objects.

Therefore, the first direction studies the product of human intellectual activity and its structure, and focuses on the realization of the product through the instruments of modern technics. That modelling of the machine intelligence systems is achieved by using the laws of formal logic, set theory, graphs, semantic networks, and other scientific advances in the field of discrete computing. The main results are in the creation of expert systems, natural language parsing systems and the simplest control systems of the <stimulus-reaction> form. Therefore, the success of the first direction of the artificial intelligence is closely related with the development of computer capabilities and programming. So that, it involves the complex of scientific and technical research as computer sciences.

The second direction of artificial intelligence considers data of the neurophysiological and psychological mechanisms of intellectual activity, generally, as a rational human behavior. The direction represents mechanisms through the various technical devices, in case that the "behavior" of such devices concurs with a human behavior according to the certain limits. The development of this area is closely related to

the studying of human sciences. It includes wider spectrum of rational human activity comparing with the machine intelligence. The artificial intelligence systems are based on the mathematical interpretation of the activity of the human brain nervous system. Thus, they are realized as neural networks, based neural element as an analog of a neuron.

2. Entry requirements

The PhD programme is allowed to persons who have a "Master" degree and working experience at least 1 (one) year or, who have completed residency studying.

Enrollment is carried out by the special commissions of the university and scientific organizations according on the results of the entrance exam of PhD educational program. Also, PhD applicants should have the certificate with the level of the foreign language in accordance with the common European competencies (standards) of foreign language.

The students have the opportunity to choose the educational programme by themselves. Enrollment on the granted programme is based on the competition.

The enrollment procedure of that programme is set by the “Typical rules of the enrollment to the educational organizations of the post-secondary and post-graduate programmes”

The contingent is formed by the state educational order to the preparation of the future academic and teaching professionals. Also, the programme involves the consideration of students, who are able to pay for their education by themselves or using other sources, organizations.

The citizens of the Republic of Kazakhstan have rights to get the state grant through the participation in the competition.

3. Requirements for completion of the course and receiving the diploma

The PhD dissertation defense is confirmed in the closing stages of the PhD programme.

The defense of the PhD dissertation is controlled by the by the Dissertation Council at the university or, by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan.

Those, who has completed the whole curriculum programme will receive the PhD degree.

PhD persons should perform the post-doctoral program or conduct the scientific research under the guidance of a leading scientist for deeper learning of scientific and applied problems.

3.1 Requirements to the key competencies of the graduates:

have an idea about:

- the key milestones of development and paradigm change of the science evolution;
- the knowledge domain, worldview and methodological specifics of natural (socio-humanitarian and economic) sciences;
- scholarly traditions of the suitable area, and their theoretical and practical studies;
- scientific outlooks of the world and Kazakhstan science in terms of the suitable area;
- adaptation of scientific studies into the practical activity;
- standards and rules of cooperation in the scientific commonwealth;
- pedagogical and science-based ethics;

know and understand:

- contemporary trends, directions and common factors of national science in terms of globalization and internalization;

– achievements of the world and Kazakhstan science in terms of the suitable area;
– the social amenability to the science and education;
– the foreign language to the communications with the scientific commonwealth;

be able to:
– organize, plan and implement the research process;
– analyze, evaluate and compare various theoretical concepts in the field of research and make decisions;
– analyze and process information from various sources;
– conduct an independent scientific study, characterized by academic integrity, based on modern theories and methods of analysis;
– generate own new scientific ideas
– share the knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge;
– choose and effectively use modern research methodology;
– plan and predict the further professional development;
–

have skills of:
– critical analysis, evaluation and comparison of various scientific theories and ideas;
– analytical and experimental research activities;
– planning and forecasting research results;
– public speaking at international scientific forums, conferences and seminars;
– scientific writing and scientific communication;
– planning, coordinating and implementing research processes;
– systematic understanding of the field of study and demonstration of the quality and effectiveness of selected scientific methods;
– participation in scientific events, fundamental scientific domestic and international projects;
– leadership and team management;
– responsible and creative attitude to scientific and scientifically pedagogical activity;
– conducting of the patent search and experience of the transferring scientific information using modern information and innovative technologies;
– protection of the intellectual property rights for scientific discoveries and studies;
– the free communication by the foreign language;

be competent:
– in the field of scientific and educational activities in case of rapid updating and growth of information flows;
– in carrying out of the theoretical and experimental research;
– in the formulation and solution of theoretical and applied problems in scientific research;
– in the realization of the professional and comprehensive analysis of problems in the relevant field;
– in matters of interpersonal communication and human resource management;
– in matters of the university's training of the specialists;
– in the examination of scientific projects and research;
– into ensuring of the permanently professional growth.

3.2 Requirements to the internship realization:

The internship is performed in order to develop the practical skills of the scientific work and

professional activity.

The educational program involves:
1) academic internship;
2) work experience internship.

The first one is realized with the purpose of studying of the modern theoretical, methodological and technological achievements of domestic and foreign science.

The work experience internship is performed to transfer theoretical knowledge into practice for improvement the professional level of the students.

4. Educational plan

year of study	Code	Name of course	Component	Credits		lecture/ laboratory/ practice	Prerequisites	Code	Name of course	Component	Credits		lecture/ laboratory/ practice	Prerequisites
				ECTS	Midterm Examination						ECTS	Midterm Examination		
1	**1 semester**							**2 semester**						
	MET321	Research methods	BD IC	5	3	2/0/1		AAP345	Doctoral student research work, including internships and doctoral dissertations	DSRW	24	8		
	LNG304	Academic writing	BD IC	5	3	2/0/1		AAP350	Pedagogical practice	BD	10	3		
	MAT149	Mathematical modelling of the physical processes	PS OC	5	3	2/0/1								
		Elective course	PS OC	5	3									
		Elective course	PS OC	5	3									
		In total		**25**	**15**				**In total**		**34**	**11**		
2	**3 semester**							**4 semester**						
	AAP345	Doctoral student research work, including internships and doctoral dissertations	DSRW	24	8			AAP346	Doctoral student research work, including internships and doctoral dissertations	DSRW	25	8		
	AAP349	Research scientific training	PS	10	3									
		In total		**34**	**11**				**In total**		**25**	**8**		
3	**5 semester**							**6 semester**						
	AAP346	Doctoral student research work, including internships and doctoral dissertations	DSRW	25	8			AAP346	Doctoral student research work, including internships and doctoral dissertations	DSRW	25	8		

								ECA303	Writing and defending doctoral dissertation	FA	12	4		
		In total		**25**	**8**				**In total**		**37**	**12**		
									In all		**180**	**65**		

Catalog of elective disciplines

Name of the discipline	**Cycle**	**Credicts**	**Lec/labs/pr**	**Prerequisits**
Quantum programming for data analysis	BD OC	5	2/0/1	
Adaptive traffic management	BD OC	5	2/0/1	
Artificial neural networks	BD OC	5	2/0/1	
Model theory	BD OC	5	2/0/1	
Machine learning methods	BD OC	5	2/0/1	
Python for deep machine learning	BD OC	5	2/0/1	
Mathematical statistics and stochastic processes	BD OC	5	1/0/2	
Big data processing methods	PS OC	5	2/0/1	
Blockchain	PS OC	5	2/0/1	
Computer architecture (Computer Architecture & Concurrency)	PS OC	5	2/0/1	
Quantum mechanics	PS OC	5	2/0/1	
Applied and nonlinear dynamics	PS OC	5	2/0/1	
Modern questions in the theory of partial differential equations.	PS OC	5	2/0/1	
Applied information theory	PS OC	5	2/0/1	
Additional questions in the theory of equations of mathematical physics	PS OC	5	2/0/1	
Interfaces of multicore systems	PS OC	5	2/0/1	
Partial differential equations on complex sets	PS OC	5	2/0/1	
Modeling in porous systems	PS OC	5	2/0/1	

MODULAR CURRICULUM

The cycle	**Code**	**Name of disciplines**	**Semester**	**Acad. credits**	**lec.**	**lab.**	**prac**	**IWS**	**Type of control**	**Chair**
Module of profile study										
Basic disciplines (BD) (28 credits)										
Institute component (IC)										
BD 1.1.1	MET321	Research methods	1	6	2	0	1	3	Exam	ELD
BD 1.2.1	LNG304	Academic writing	1	6	2	0	1	3	Exam	MPHETSM
Practice-oriented module										
	AAP350	Pedagogical practice	2	10					Report	SMC
Principal subjects (PS) (28 credits)										
Institute component (IC)										
Module of mathematical study										
PS 1.1.1	MAT149	Mathematical modeling of physical processes	1	6	2	0	1	3	Exam	SMC
Optionally component (OC)										
Module of basic study										
PS 2.1.1.	MAT241	Mathematical statistics and stochastic processes	1	6	1	0	2	3	Exam	SMC

PS 2.2.1.	MAT207	Model theory	1	6	2	0	1	3	Exam	SMC
Practice-oriented module										
MD	AAP349	Research scientific training	3	10					Report	SMC
Scientific-research module										
DSR W	AAP345	Doctoral student research work, including internships and doctoral dissertations	2	24					Report	SMC
DSR W	AAP345	Doctoral student research work, including internships and doctoral dissertations	3	24					Report	SMC
DSR W	AAP346	Doctoral student research work, including internships and doctoral dissertations	4	25					Report	SMC
DSR W	AAP346	Doctoral student research work, including internships and doctoral dissertations	5	25					Report	SMC
DSR W	AAP346	Doctoral student research work, including internships and doctoral dissertations	5	25					Report	SMC
Module of final attestation										
FA	ECA303	Writing and defending doctoral dissertation	6	12					Defense of the master's thesis	SMC
Total				185						

5. Descriptors of the level and content knowledge, skills and competences

In the process of mastering the educational program, the Bachelor of Technology and Technology must have the following key competencies.

A - knowledge and understanding:

A1 are scientific principles based on the study of general professional and special disciplines, containing both basic and in-depth courses for fundamental training in mathematical and computer modeling.

A2 - organizations of computing systems; Designing digital devices Application of languages and programming technologies knowledge of the mathematicalbasics.

A3 - system analysis methodology; Designing and making decisions in complex and professional situations Ways to communicate and reconcile points of view; design and presentation of analytical and project documentation.

In the application of knowledge and understanding:

B1 - to analyze the subject area, identify goals and how to achieve them;

B2 - for self-development and nomination of various options for solving professional problems using theoretical and practical knowledge;

B3 - to build mathematical models with real-world

Conditions to optimize different processes.

C - the formation of judgments:

C1 - about current trends in mathematical and computer modeling;

C2 - about modern approaches in mathematical modeling with the use of artificial intelligence to solve fundamental and production problems,while being able to compare, shape conclusions, build their own reasoning, express and justify their position;

D - personal abilities:

D1 - awareness of the social importance of the profession, adherence to the principles of professional ethics, improving the professional and personal qualities of a specialist in the field of mathematical and computer modeling;

D2 - the desire to develop intellectual, moral, communicative, organizational and management skills;

D3 - the ability to listen, convince and argue, the ability to find a compromise, to correlate their opinion with the team, the ability of public professionally -oriented communication;
D4 - the ability to organize the collection, storage and processing of information used in the field of professional activity, in global computer systems, networks, library funds and other sources of information.

6. Competence at the end of training

B - Basic knowledge, skills and skills:
B1- to be able to analyze the current problemsof the modernhistory of Kazakhstan;
B2 - to know and apply in practice the basics of engineering professional Ethics
B3 - to know the modern and promising directions of information technology development and mathematical methods of optimization.

P - Professional competencies, including in accordance with the requirements of industry professional standards:
P1 - a wide range of theoretical and practical knowledge in the professional field;
P2 - the ability to organize, provide, design mathematical models and implement them with the help of artificial intelligence and information technology.

A - Human, social and ethical competences:
A1 - the ability to constantly learn, to focus; Be confident in uncertainty. Have a high level of spatial and logical thinking;
A2 - the ability to work in a team, to have organizational skills, to prioritize, to quickly learn new knowledge and skills, to apply them in practice;
A3 - to be results-oriented, to plan effectively and organize one's development;
A4 - the ability to freely use English as a means of business communication, a source of new knowledge in the field of mathematical and computer modeling.

S - Special and management competencies:
S1 - self-management and control of work and training processes within the framework of the organization's strategy, policy and objectives, critical discussion of the problem, reasoning conclusions and competent operation of information;
S2 - the ability to motivate to solve certain problems, the ability to be responsible for the result of work at the level of a unit or enterprise;
S3 - the ability to demonstrate a set of work management skills, the ability to choose methods, techniques and evaluation criteria to obtain results, distribute and delegate authority, form teams, and make decisions during the production process.

7. Diploma Supplement ECTS

ECTS – European Credit Transferand Accumulation System (European system of translation and scoring accumulation) is a pan-European system for taking into account the academic work of students when mastering an educational program or course. In practice, the ECTS system is used in the transition of students from one educational institution to

another throughout the European Union and others who have adopted this system, European countries, including the Republic of Kazakhstan.

To get a bachelor's degree you need to get 240 in academic credits.

The app consists of 8 obligatory items in English/Kazakh/Russian languages. It is a standardized text that confirms that the application is compliant with European standards. The form of the European diploma application is shown in Annex A.

Section 1 Information about the qualification holder: the name, name (as recorded in the passport), date and place of birth, identification number or student code are specified.

Section 2 Information on the qualification received: qualification name, major specialty, additional minor specialty (if available), name and status of a higher education institution, which assigned qualifications in the native language, the name and status of a higher education institution, the qualification in English, the language of instruction and control of knowledge.

Section 3 Information on the level of qualification: indicates the level of qualification - bachelor's degree (master's degree, doctorate), duration of study, requirements for admission.

Section 4 Information on the content of the training and the results: the form of education is specified - full, remote, abbreviated full, the requirement of the program (the required volume for the mastery of the program), the content of the educational program (mandatory and elective disciplines, student coursework, completed practices, protected diploma work indicating the laboriousness of disciplines, practices, coursework and diplomas, status (mandatory, by choice, additional), final assessments) in loans of RK and ECTS, national assessment scale approved by the order of MONRC and its description, the mechanism of transfer of assessments to the European system, general classification of qualifications.

Section 5 Professional qualifications: whether the qualifications are available to advance to the next stage of education and what requirements to do so must be met, professional status (which professional rights are acquired by students with qualifications).

Section 6 Additional information: additional information about the university, additional sources of information.

Section 7 App Certification: specified the date of qualification, the date of issuance, the name, the name of the official certifying the application to the diploma, signing the diploma itself; all of this information is sealed.

Section 8 Information on the National Higher Education System.

This application is issued only at the end of the university on the application of the graduate on a remunerative basis in accordance with the standards set by the university.

To receive the application, you must submit a written (electronic) application to the university office with an application copy of the receipt.

The application is issued by the Office registrar within 15 business days of application and is registered in the journal of issuance and registration of diplomas and applications. Application form forms are stored in the Registrar's Office.

8. Description of the courses

1. Professional English

Code – LNG205
Credits – 3 (0/0/3)
Prerequisites –Academic English, Business English, IELTS 5.0-5.5

Description of the discipline

The goal of professionally oriented English is the development of the professional competencies of master students and improvement of their ability to study effectively in English; the formation of professionally oriented communicative competence of postgraduates that allows them to integrate into the international professional environment and use professional English as means of intercultural and professional communication.

Project Management *(Management + Business Psychology)*
Code - MNG230
Credits - 2
Prerequisites – Project management (Bachelor)

BRIEF DESCRIPTION OF THE COURSE
The content of the discipline is aimed at studying modern concepts, methods, and tools of project management in order to apply them in the further practical activities of a specialist to solve problems of project planning and execution.

Python
Code
Credits -2 (1/0/1)
Prerequisites –

Description of the discipline
The Python programming language is a modern and popular course based on the formation of basic concepts of object-oriented programming, the development of system thinking of students.
In connection with the development and implementation of information and communication technologies in everyday life, the need for effective software development tools has increased. The Python programming language is a powerful tool for creating programs for a wide variety of purposes, available to students of different levels of training. Python is an interpreted, object-oriented, high-level programming language with dynamic semantics.
KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
Basic Python programming and Python code design style.
be able to:
competently program in Python;
solve standard tasks of professional activity in Python.
possess: the

ability to solve standard tasks of professional activity on the basis of information and bibliographic culture with the use of information and communication technologies and taking into account the basic requirements of information security.

Machine learning methods

CODE –

CREDIT – 3 (1/0/2)

PREREQUISITE-MAT128, MAT 134, MAT124

PURPOSE AND OBJECTIVES OF THE COURSE

The purpose of the discipline is to train specialists who know the basic machine learning skills: Supervised, Unsupervised, Reinforcement Learning

The objectives of the course

- Development of the basic Python libraries
- The manipulation of data
- Optimization of models

BRIEF DESCRIPTION OF THE COURSE

1. Pandas, Numpy, Scipy, MySql, SQLite, SQLAlchemy, Seaborn, Matplotlib, Bokeh, Scrappy.
2. Processing CSV, XLS, and JSON files.
3. Supervised, Unsupervised, Reinforcement Learning
4. Case studies.

KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE

A master's student should know:

- Pandas, Numpy, Scipy, MySql, SQLite, SQLAlchemy, Seaborn, Matplotlib;

The master's student must be able to:

- - must be able to work on Anaconda, Spyder, Jupiter notebook
- solve problems of classification, regression, clustering, etc.;
- process big data;
- Scraping, Wrangling, crawling data.

Artificial neural networks

CODE –

CREDIT – 3 (1/0/2)

PREREQUISITES-MAT134, MAT128, neural networks, basic Python libraries, optimization, graph theory.

PURPOSE AND OBJECTIVES OF THE COURSE

The purpose and objectives of teaching the discipline are to master modern neural network architectures, as well as their applications in NLP, pattern recognition.
BRIEF DESCRIPTION OF THE COURSE
1. Feed forward, Back propagation, Gradient Descent, Stochastic Gradient Descent
2. CN, RN, LSTM on Pwtorch for solving classification and regression problems
3. Pipelining on Karas
4. SQLAlchemy, SQLite
5. Bokeh
6. Seaborn
KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
A master's student should know:
- basic Python libraries;
- mathematical basis of modern deep neural networks
A master's student should be able to:
- Build deep neural networks
- Optimize deep neural networks

Blockchain
CODE –
CREDIT – 3 (1/0/2)
PREREQUISITE-cryptography

PURPOSE AND OBJECTIVES OF THE COURSE
Purpose of the discipline
Teach you how to develop decentralized applications based on Solidity and JavaScript.
Tasks of the discipline
- mastering the Solidity language
- - mastering the JavaScript language and developing the blockchain
- development of decentralized applications
BRIEF DESCRIPTION OF THE COURSE
- cryptographic foundations of the blockchain, RSA, ECC protocols
- Solidity
- - JavaScript
-decentralized applications
KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
As a result of studying the discipline, you should know:
- cryptographic foundations of the blockchain, RSA, ECC protocols;
- the language of Solidity;

As a result of studying the discipline should be able to:
- build decentralized applications on Solidity;

Specialized programming languages
CODE –
CREDIT – 3 (1/0/2)
PREREQUISITE –

THE purpose AND OBJECTIVES of the COURSE is to introduce undergraduates to methods
and algorithms for finding optimal solutions to various problems.
BRIEF DESCRIPTION OF THE COURSE
R is a programming language for statistical data processing and working with graphics, as well as a free and open source computing environment within the GNU project. R supports a wide range of statistical and numerical methods and has good extensibility with packages. Packages are libraries for specific functions or special applications.
Another feature of R is the ability to create high-quality graphics that can include mathematical symbols.
KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
After passing the course the student should:
First, have an idea about the main stages of solving problems on a computer, the quality criteria and stages of the life cycle of software products, principles and techniques of user interface design programs.
Second, you must know: representation of basic programming structures: iteration, branching, repetition; procedures; user-defined data types; records; files; dynamic data structures.
Third, you must be able to: design and implement programs in a high-level language.

Interfaces of multicore systems
CODE –
CREDIT – 3 (1/0/2)
PREREQUISITE-MAT101, MAT 102, MAT 103
The goals and OBJECTIVES of the COURSE are to familiarize undergraduates with the basic principles, methods, concepts and paradigms of parallel computing and parallel program development, as well as to teach them to develop and implement parallel algorithms based on MPI, OpenMP, OpenACC technologies using cluster and supercomputer systems.
BRIEF description of the COURSE-the course covers the basic concepts of parallel computing and parallel programming. The course contains the following topics: overview of parallel computing systems and their classification, characteristics of multiprocessor and multicore systems, performance evaluation of parallel computations, analysis of

computational complexity and parallelization an overview of the development of methods for parallel programming for systems with shared and distributed memory. During the course, undergraduates acquire skills in developing parallel programs in the C++ programming language using MPI, OpenMP, and OpenACC technologies.
KNOWLEDGE, SKILLS, SKILLS AT the end of the COURSE-at the end of the course, the master student must know and understand the principles and techniques of parallel computing, be able to determine the main characteristics of parallel systems, be able to develop parallel programs for systems with distributed memory based on MPI, implement multithreaded programs using OpenMP technology, and create heterogeneous programs using the OpenACC standard.

Applied information theory
CODE –
CREDIT – 3 (1/0/2)
PREREQUISITE-MAT124

PURPOSE AND OBJECTIVES OF THE COURSE
- The concept and types of information systems.
- The concept of management as a science.
- The concept of entropy, information and methods for their evaluation.
- Methods of quantitative assessment of information.
- Theoretical and practical aspects of optimal (efficient) coding.
- Theoretical and practical aspects of noise-tolerant coding.
- Models of signals, data transmission systems, modulation and demodulation, signal sampling.
- Application of the theory of noise-tolerant coding in data processing systems.

BRIEF DESCRIPTION OF THE COURSE
This course focuses on information theory, which is the theoretical basis of information and communication technologies. Information theory explains many key aspects of communication and data processing. The theory considers the concepts of entropy, information, optimal coding methods, noise-tolerant coding methods, and signal models. Recently, information theory has been successfully applied in machine learning and artificial intelligence tasks.
The purpose of this course is to explain the fundamental concepts of information theory and illustrate their applications. The course provides some methods for prototyping software based on linear algebra and information theory. During the course, undergraduates will gain theoretical knowledge and practical skills in the development of software of this type
KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
KNOWLEDGE:
• Understand what is entropy and information,

* Understand effective coding techniques,
* Understand noise-tolerant coding techniques
• To understand the mathematical models of signals
* Determine when and why certain signal and data processing methods should be used.

SKILLS: software for data processing based on information theory
SKILLS: information theory methods for solving practical problems (coding, cryptography, data processing)

Econometrics
CODE-MAT206
CREDIT – 3 (2/0/1)
PREREQUISITE – MATH 128

PURPOSE AND OBJECTIVES OF THE COURSE
Introduction to regression analysis for testing economic hypotheses and quantifying economic relationships. Teach students to use statistical software to analyze economic models.
BRIEF DESCRIPTION OF THE COURSE
Regression analysis: the least squares Method.
Properties of regression coefficients: unbiased, consistency, evaluation efficiency, confidence intervals, p value.
Multiple regression analysis: multicollinearity, F-test, coefficient of determination.
Dummy variables: regression with dummy variables, interpretation of coefficients.
Model specification: regression with constraints, t-test for constraints, multiple constraint tests.
Heteroskedasticity: tests for heteroskedasticity, correction of standard errors for heteroskedasticity, weighted least squares method.
Endogeneity: evaluation failure, the method of instrumental variables.
Discrete choice models: Logit, probit models, maximum likelihood method.
KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE
Use linear regression to analyze cross-sectional data. Understanding problems related to violation of Gauss-Markov conditions. Use the method of instrumental variables for regression analysis in the presence of an endogenous variable. Use logit and probit models to analyze discrete choice models. Understand the principle of the maximum likelihood method.

Discrete mathematics
CODE –
CREDIT – 3 (1/0/2)
PREREQUISITE-Mathematics I, Mathematics II, Mathematics III.

PURPOSE AND OBJECTIVES OF THE COURSE

The main goal of the course is to instill skills of practical application of the basics of discrete mathematics in the process of programming, algorithmization, automation of computing processes, deepening knowledge of the computer cycle, implementation of practical tasks in the field of technical engineering.

Objectives of the course: to acquire the knowledge necessary for the effective use of rapidly developing mathematical methods; to acquire the skill of constructing and researching mathematical models; to master the fundamental sections of mathematics necessary for solving research and practical problems in the professional field.

BRIEF DESCRIPTION OF THE COURSE

The algebra of statements, Boolean variables, the basics of Boolean functions, the algebra of sets, relations of sets, fundamentals of graph theory, basics of coding theory.

KNOWLEDGE, SKILLS AND ABILITIES AT THE END OF THE COURSE

The study of this discipline will allow the master's student to apply knowledge in discrete mathematics to solving practical problems; find tools for solving and researching programming problems; solve computer science problems, improve computer technologies; deepen knowledge in the study of computer mathematics disciplines.

Defense of the master's project

CODE-ECA2013

The CREDIT is 12

The purpose of the master's thesis is to
demonstrate the level of scientific/research qualification of the master's student, the ability to independently conduct scientific research, test the ability to solve specific scientific and practical problems, knowledge of the most General methods and techniques for solving them.

SHORT DESCRIPTION

Master's thesis/project graduate qualification scientific work, which is a generalization of the results of independent studies undergraduates one of the pressing problems of a particular specialty relevant branch of science that has internal unity and reflects the progress and results of the development of the chosen topic.

Master's thesis / project – the result of research /experimental research work of a master's student, conducted during the entire period of study of a master's student.

The defense of the master's thesis / project is the final stage of the master's preparation.

The master's thesis / project must meet the following requirements –

- the work must conduct research or solve current problems in the field of operation and digital diagnostics of technological equipment in the mining, metallurgical and oil and gas industries;
- the work should be based on identifying important scientific problems and solving them;

- decisions must be scientifically sound and reliable, have internal unity;
- the dissertation work must be written alone;

The contents