

**National Technical University of Ukraine  
“Igor Sikorsky Kyiv Polytechnic Institute”**

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"29" " " 2022



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**PROGRAM**  
**ENTRANCE EXAMINATION**  
**to obtain the scientific degree of Doctor of Philosophy**  
*by specialty 184 Mining*

*The program is recommended by the academic council  
Educational and Scientific Institute of Energy Saving and Energy Management*

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## I. GENERAL INFORMATION

The entrance exam for studying for the Doctor of Philosophy degree in specialty 184 "Mining" is held for those entrants who have a master's degree\*.

The educational program "Geoengineering" corresponds to the mission and strategy of Igor Sikorsky KPI, according to which the strategic priority of the university is the fundamental training of specialists. The peculiarities of the educational program are taken into account by choosing the appropriate sections of the entrance exam program. Conducting an entrance test should reveal the level of preparation of the entrant in the specialty chosen for admission. The theoretical questions of the entrance exam can be divided into eleven sections:

1. Basics of economy, technology and mechanization of mining works
2. An open method of field development
3. Underground method of deposit development
4. Borehole geotechnologies
5. Construction geotechnologies
6. Stresses and deformations in massif rocks
7. Fundamentals of solid medium mechanics and crack theory
8. Theories of rock strength
9. Stability of sides of quarries
10. Energy of rock destruction
11. Fundamentals of loose soil dynamics

The first section contains general questions that every specialist in the field of geoengineering should know the answer to. The last ten chapters are more oriented to the special preparation of the entrant.

The task of the entrance test consists of three theoretical questions. The exam ticket includes, respectively: questions from all sections.

The entrance test for the specialty is conducted in the form of an oral exam.

The duration of the applicant's preparation for the answer is 2 academic hours.

In the next section of the program, only those topics from the specified sections that relate to the performance of the tasks of the entrance exams are given.

Information about the admission rules and requirements for entrants to the "Geoengineering" educational program is provided in the "Admission to postgraduate studies" section on the website of postgraduate and doctoral studies of Igor Sikorsky KPI at the link <https://aspirantura.kpi.ua/>

\*According to Appendix 2 of Chapter XV of the Law on Higher Education higher education at the educational and qualification level of a specialist is equated to higher education with a master's degree



## **II. SUBJECTS SUBMITTED TO THE ENTRANCE EXAMINATION**

### **1. Basics of economy, technology and mechanization of mining works**

Economic, planning and organizational-management activities up to the level enterprises using modern economic methods of management, organization of production and labor, household accounting; cooperative and lease relationships in economic activity, based on the state plan for the development of the national economy, taking into account the program and problems of the development of mining production in the country.

The main tasks of the mining industry, classification of mining industry branches. Economic assessment of mineral deposits. Production capacities and products of the mining industry. Brief technical and economic characteristics of the country's main mining basins. Definition of the economic system. Materiality of economic indicators. A schematic diagram of the formation of economic indicators in the national economy. Mathematical description of the relationships of economic indicators in the mining industry.

Resources of the mining industry. Basic funds. Reverse means. Personnel of the mining industry.

Costing and pricing in the mining industry. Profitability mining industry. Profit. Funds of economic stimulation. Finance and credit in the mining industry.

Concentration, specialization, cooperation and combination of production. Principles of location of industry.

Production balances and their optimization. Production program of the industrial association, career.

Effectiveness of scientific and technical progress in the mining industry. Historical reference on the development of mineral extraction technologies. Problems facing mining science and practice. Mining technologies of tomorrow.

### **2. Open method of development of deposits**

The concept of open pit mining. The main elements of a career. The main parameters of the career. Stages of open pit mining. Types of developed deposits. Types of open developments. Sizes of career fields. Subsoil use and nature protection. Periods of mining operations. Preparation of the career field for development. Production processes, methods and means of their mechanization. Procedure for extracting ledge rocks. Stability of sides and ledges of the quarry. General information about constructions of sides of quarries. The main indicators of career performance. Basics of safety techniques of open developments. General Information about technical and economic indicators of open mining developments.

Mining rocks as an object of development. Ways of preparing mining rocks for extraction. Technological requirements for preparation before the explosion. Blasting methods. Processes of drilling explosive wells and holes. Drillability of mining rocks. Types of drilling. Technology, mode and speed of impact, auger, pneumatic, and thermal



drilling. Oversize grinding. Organization of drilling works. Operational performance of drilling rigs. Technological conditions of blasting. Technological characteristics of VR. Reference, design and actual specific consumption of BP. Parameters of explosive wells. Technological bases of the construction of VR charges. Location of wells on the escarpment. The procedure for detonating BP charges: instant, short-delayed. Subversion schemes. Calculation of charges. Characteristics of camber. Secondary detonation. Mechanization of charging and plugging wells. Basics of safe blasting operations.

Types of potholes. Procedure for extracting ledge rocks. Extraction of rocks with scrapers. Technological parameters of the wheel scraper. Parameters of scraper pits. Productivity of scrapers.

The process of removing rocks with bulldozers. Technological parameters of bulldozers, their impact and productivity.

The process of removing rocks by a loader and their operation schemes. Productivity of loaders.

Excavation of rocks with mechanical shovels, their technological parameters. Extraction of soft rocks with mechanical shovels with different types of transport. Peculiarities of extraction in trench excavations. Excavation of blasted rock mass with quarry mechanical shovels.

Extraction of rocks by draglines, their technological parameters. Bumps of draglines. Extraction of soft and blasted rocks with loading into the vehicle and unloading into the created space. Productivity of draglines, technological bases of automation. Technical and economic indicators.

Excavation of rocks by chain excavators. Technological characteristics of chain excavators. Frontal and end dents. Productivity of chain excavators. Organization of work of excavators.

Extraction of rocks by special auger machines, well combiners, machines of continuous action for extraction of blasted rock.

Main and auxiliary quarry loads. Types of career transport for signs. Characteristics of mining rocks according to the difficulty of transportation.

Railway transport. Technological assessment and characteristics of rolling stock. Technological parameters of the railway track. Track profile. Calculation of the weight of the train. Basics of train movement organization. Mode of operation and technical productivity. Dumping during railway transport. Technological connections of extraction and dump formation processes. Dumping with mechanical shovels, draglines, multi-bucket excavators, bulldozers, scrapers, loaders, hydraulic dumping. Organization of unloading works. Technological bases of automation of transportation and unloading operations.

Road works. Parameters of road-laying works and connection with elements of the development system and equipment parameters. Moving and rearranging the track. Economic indicators of road construction works. Requirements of safety rules for railway transport, dump and unloading works, and road works.

Automobile transport. Technological characteristics of rolling stock (dump trucks, wheeled tractors, trolleybuses, diesel trolleybuses, quarry road trains). Career paths. Throughput and transportation capacity of career paths and nodes. Technological foundations of motor vehicle automation. Technical and economic indicators of motor



vehicles. Safety requirements and safety rules for road transport.

Conveyor transport. Technological characteristics and parameters of conveyors. Dumping and unloading processes. Productivity of conveyors. Auxiliary works. Technological bases of conveyor automation. Technical and economic indicators.

Combined and special types of transport. Technical and technological conditions for the use of combined transport, technological schemes. Quarry ore descents and ore slides, rope ascent. Cable cranes and excavators. Extraction and movement of artificial, sawdust, sand, etc. Mining and transportation of precious stones.

Reclamation of disturbed lands. Technological schemes and methods of mechanization of mining reclamation.

Peculiarities of mining processes for construction purposes. Characteristics of construction mining rocks and products from them. Processes of extraction of crushed stone, blocks for the production of facing plates and sawdust.

Division of the quarry field into mining layers, the height of the ledge, the length of the work front, the speed of the work front. General concepts of development systems. Classification of development systems.

Basics of complex mechanization. Technological classification of equipment complexes. Factors affecting the productivity of mining and transport machines and equipment complexes. The basics of assembly and the relationship of loading and unloading and transport equipment, the scope of use and its influence on the economic indicators of development.

The procedure for extracting and moving overburden into dumps. Basics of calculation of the unfolding technological complex. Parameters of the development system. Scope and technical and economic indicators of excavator-dumping technological complexes and excavation schemes. Safety rules. Transport technological complexes.

Technological complexes and excavation schemes with conveyors, rail and road transport. Mining and transport machines. Combined technological complexes. Technical and economic indicators. Basics of the theory of the working process of stone-cutting machines. Fundamentals of the theory of cutting with diamond ropes. Organization of work.

### **3. Underground method of deposit development**

Historical development of mining equipment and technologies. Concept of underground mining, opening and preparation of mine field. Mineral deposit discovery systems, classification. Methods of opening with vertical shafts, inclined shafts. Division of the mine field into floors (floors) and panels. Panel and horizontal methods of mine field preparation. Block training. Connection of methods of disclosure and preparation.

The concept of mountain pressure. Manifestation of pressure during the construction and operation of mining works. Types and constructions of fastening of mining products. Methods of rock destruction and mining. Production processes. The concept of technological schemes for carrying out horizontal and inclined workings by combine harvesters and by drilling and blasting. Methods of drilling, arrangement of



holes in pits, order and efficiency of blasting, organization of work. Peculiarities of drilling inclined workings. The concept of the technology of conducting vertical trunks.

Extraction processes, methods of coal destruction, technology of coal extraction by harvesters on a gentle and inclined fall. Organization of work in the bench. Peculiarities of coal mining in steep layers. Extraction of coal seams with planers. Technological schemes of cleaning pit for inclined and steep fall. Roof management in pothole cleaning, management methods. Fastening of cleaning potholes, types of fastening.

Features of occurrence, opening and preparation of iron ore deposits. Methods of ore chipping, secondary crushing. Delivery and loading of ore. Management of mountain pressure. Systems of development of ore deposits.

Underground transport processes. Tasks and structure of transport, types of main and auxiliary transport. Technological processes in the surrounding trunk yard. Composition of atmospheric and mine air. Properties and norms of methane content, types of its release in production, concept of gas capacity, categorization of mines. Mine dust, types and methods of dust control. Thermal mode of mines. The concept of calculating the main parameters of ventilation. Methods and schemes of ventilation of dead-end workings, ventilation of mines.

#### **4. Borehole geotechnologies**

Features of occurrence of oil and gas deposits. Drilling of oil and gas wells, equipment, direction setting. Bush wells of controlled direction. Drilling technique. Oil and gas extraction technology. Preparation, transportation, storage and processing of oil and gas.

Geotechnological ways of extracting minerals. General regularities and physical and chemical processes of geotechnologies. Classification of geotechnological mineral extraction systems. Assessment of geological and mining technical conditions favorable for the application of mining geotechnology. Prospects of their use for the development of mineral deposits of Ukraine. Extraction of minerals by leaching. Underground coal gasification. Production of shale gas and oil. Well development of underwater minerals and gas hydrates.

#### **5. Construction geotechnologies**

Construction of underground structures by open method. Construction in open pits. Trench method. "Wall in the soil". Use of mobile mount. Shield technology of tunnel construction. Constructions of walk-behind shields, their classification. Work technology when using semi-mechanized and mechanized shields. Designs and construction of frames (fastening). Fixed tamponage. Organization of works with shield technology. Schematic diagram of micro-board technology. Materials and structures of pipelines. Schemes of works. Experience and prospects for improvement of MSHT. Puncture (the essence of the method and conditions of use). Ground-piercing devices. Pipeline laying technology. Pressing (essence and field of application of the method). Designs of pressing units. Work



technology. Directional drilling (the essence of the method and its development). Equipment for directional drilling of wells, work technology. Construction of tunnels by mining method with the help of BPR. Construction in soft and cracked rocks. Construction in solid rocks. Methods of tunnel crossing of fault zones. Directions for improving the mining method. Construction of tunnels with the help of combine harvesters and tunneling complexes. The essence of the method and conditions of its application. Classification of walk-behind combines and complexes. Work technology. Experience of world practical use. Construction of tunnels in difficult hydrogeological conditions. Method of water reduction. Construction under compressed air. Soil freezing. Tamponage method. Construction by the lowering method. Construction of underground structures of the chamber type. Peculiarities of designing the shape of the camera and choosing its mounting. Diagrams of the opening of the cross section. Technologies for the construction of chambers in rocky, semi-rocky and soft rocks. Fastening erection technology. Mechanization of works. Types of mine underground storages and their use. Mine-type gas and oil storage facilities. Practical experience in the construction of mine-type storage facilities. Construction of underground storage facilities in salt deposits. Construction of storage facilities in clay massifs with the use of camouflage explosions: the essence of the method, requirements for the engineering and geological environment, the technology of drilling and blasting, fixing the surface of the product with sprayed concrete, examples of practical application of the method.

## **6. Stresses and deformations in massif rocks**

Mechanics of rocks as mechanics of a deformed solid body. Mechanical properties of rocks. External and internal forces. Normal and tangential loads. Internal forces and tension. Mechanical properties of rocks. Limit of elasticity, proportionality. Yield strength. Strength limit. Solid body load diagram. Peculiarities of rock deformation. Complete diagram of rock deformation.

Displacement in rock under load. Relative linear deformation. Distance between points before and after deformation. Guide cosines. Equations for linear deformations. Change of angles in a solid during deformation. Shear deformation. Shear strain angles and corresponding equations.

Strain tensor in rocks. The main elements of the strain tensor. Linear, plane and volumetric deformations. Invariants of the strain tensor. Small deformations. Speed of displacement and deformation. Strain tensor in different coordinate systems.

Stress in rocks. Stress tensor. Main voltages. State invariants voltage Linear stress state. Flat voltage state. Deformation energy. Kinetic energy of body particles during deformation. Potential energy of deformation. The corresponding equations.

## **7. Fundamentals of solid medium mechanics and crack theory**

Basic equations of the mechanics of a solid medium. The transition from stresses at a point to the distribution of stresses over the entire volume of the loaded array. Using the



Dalembert-Euler principle to describe the equilibrium in rocks. Equations of dynamic and static equilibrium. Constituent equations. Tensor notation of the equilibrium equations of a continuous medium. Equilibrium equation for a flat state of stress. The relationship equation of the components of the strain tensor and displacements in the array (Cauchy equation). Saint-Venant equation. Methods of elasticity theory. Necessary and sufficient conditions for describing the deformed state of a massif of rocks. Physical theories of geomechanics. Elastic properties of rocks. Elastic deformations. Elasticity potential. Hooke's law in tensor form (general case, anisotropic medium). Hooke's law for an isotropic medium. Statement of problems of the theory of elasticity, schemes and solution methods. Erie function. Biharmonic equation and its solution.

Methods of plasticity theory. Plastic deformations. Henka's equations and their analysis. Tensor notation. Statement of problems of the theory of plasticity and their schemes solution Using a computer to solve the equations of plasticity theory.

Methods of the theory of limit equilibrium. Equation of static equilibrium. Equilibrium equation at ultimate stress, method of V.V. Sokolovsky for solving problems within the framework of the theory of the limit stress state. The equation of slip lines in the soil massif and the method of their solution.

Methods of the theory of the state beyond the limit stress. Complete diagram of rock deformation. Characteristic points of the diagram. Peculiarities of the behavior of rocks in a state of extreme stress. Deformation indicators of rocks under extra-limital stress.

The equation of the state theory beyond the limit stress. A flat static problem for a mountain massif in a state of extreme stress. Equation of static equilibrium. Physical equations of the theory of the state of non-boundary stress. Formulation of problems within the framework of the theory of the state of non-boundary stress and methods of their solution.

Types of cracks in the mountain massif. Model of a normal separation crack. Displacement of the crack banks. A system of equations for a plane static problem in an isotropic array. Erie function. Biharmonic equation. Polar coordinates. System of equations in polar coordinates. Williams solution. Shear stress near the crack tip. Voltage intensity factor. Irwin's approach. Normal separation. Planar and antiplanar shear.

## **8. Theories of rock strength**

Phenomenological theories of rock strength. The first theory of strength (theory Galileo). The second theory of strength (Ponsele's theory). Criterion of the largest linear deformation. The third theory of strength (Cod theory). Criteria for maximum normal and tangential stresses. The fourth theory of strength (Huber-Mises-Hankey theory). Energy deformation theory. The energy of changing the shape of the deformed volume. Destruction condition. Criterion of the largest linear deformations.

The theory of strength based on the hypothesis of a sliding platform. Hill-Trisk theory of strength. The main equation. Coulomb-Mohr strength theory. Output parameters. The main equation. Mises-Schleicher-Botkin strength theory. The location of the shear plane in space. Equations and parameters.

Kinetic theory of destruction. Changes in the energy state of a loaded rock sample



over time. Sample loading time. Arrhenius-Zhurkov equation. Stress concentration on cracks. Analysis of the strength limit of rock rocks in uniaxial tension from the point of view of the kinetic theory of strength.

## **9. Stability of sides of quarries**

Patterns of the formation of the loaded state in the sides of the quarry. Comparison of the state of disturbed and undisturbed arrays. Change in the state of stresses during quarry construction. Equilibrium equation, Saint-Venant equation, Hooke's equation for the edge of a quarry as a plane static problem in an isotropic array. Substitution of variables and transformation of the original equations. Solutions by the methods of complex potentials and the Ery function. Expressions for calculating principal stresses and their analysis. Plots of the distribution of the main stresses in the massif of the side of the quarry. Tangential stresses in the boron array of the quarry, their calculation, analysis, distribution in space. Stability of sides and dumps of quarries. Deformations and destruction of rock massifs.

## **10. Energy of rock destruction**

Granulometry of geomaterials. The physical essence of crushing rocks during their destruction. Granulometric composition of destroyed rocks. Shape and size of particles of destroyed rocks. Equivalent diameter. Volume coefficient. Measure of sphericity. Methods of determining the granulometric composition of destroyed rocks. Regularities of distribution and mathematical description of granulometric composition. Empirical regularities: Martin's, Weining's, Godin-Andreev's, Andreasen's formulas. Analytical regularities: Rosin-Ramler (Weibull), lognormal.

Energy regularities during the destruction of rocks. Energy balance during the destruction of rocks. Energy intensity of destruction. Energy criterion during destruction. Generalized classification of rocks during their destruction. Classification of rocks during drilling, blasting, excavation, crushing and their relationship with the generalized classification of rocks during destruction.

## **11. Fundamentals of loose soil dynamics**

Mathematical models used for solving problems of soil dynamics. Methods of experimental research in the dynamics of loose soils. Results of theoretical studies of wave processes in loose soils. Results of experimental studies of wave processes in loose soils.

Compaction and loosening of loose soils by dynamic loads. Mechanical effect of camouflage explosion in soils. The effect of the explosion on the release of soil. The effect of anthropogenic factors on the mechanical properties of soils.



### III. EDUCATIONAL AND METHODOLOGICAL MATERIALS

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2. Гайко Г.І., Білецький В.С. Історія гірництва: Підручник. – Київ: Видавничий дім «Києво-Могилянська академія», 2013. – 566 с.
3. Білецький В.С., Гайко Г.І., Орловський В.М. Історія та перспективи нафтогазовидобування: Навчальний посібник. – Київ: ФОП Халіков Р.Х., 2019. – 302 с.
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9. Проектування каменеобробних підприємств. Ч. II : навч. посібник / С.С. Іськов, В.В. Коробійчук, В.Г. Кравець, Р.В. Соболевський, А.О. Криворучко, О.М. Толкач. – Житомир : ЖДТУ, 2018. – 248 с.   
Url: <http://ela.kpi.ua/handle/123456789/23569>
10. Ресурсозберігаючі технології при будівництві геотехнічних об'єктів / Зуєвська Н.В., Зайченко С.В., Шайдецька Л.В., Вапнічна В.В. / [Електронний ресурс] **монографія** КПІ ім. Ігоря Сікорського, 2018 р. – 202 с.   
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11. Резонансне енергоощадне руйнування гірських порід: [Електронний ресурс] **монографія** / том1. Обертове магніто- гідродинамічне кавітаційне руйнування вибоїв / О.М. Терент'єв, А.Й. Клещов, П.А. Гонтарь, О.Я. Тверда. – К.: КПІ ім. Ігоря Сікорського, 2018. – 149 с. <http://ela.kpi.ua/handle/123456789/23336>
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#### IV. RATING SYSTEM FOR ASSESSING THE ENTRANCE EXAMINATION

1. The applicant's initial rating for the exam is calculated based on a 100-point scale. When determining the general rating of the entrant, the initial rating for the exam is recalculated into a 200-point scale according to the corresponding table (item 4).

2. At the exam, applicants prepare for an oral answer to the task of the exam ticket.

Each task of the complex professional entrance test contains three theoretical questions. The questions are general in the field of production and technology and are focused on the special training of the entrant.

The task (1-3 questions) is evaluated at 30, 30 and 40 points each according to the evaluation system:

- **"excellent"**, the student has firmly mastered the theoretical material, has a deep and comprehensive knowledge of the content of the academic discipline, the main provisions of scientific primary sources and recommended literature, thinks logically and constructs an answer, freely uses the acquired theoretical knowledge when analyzing practical material, expresses his attitude towards certain problems, demonstrates a high level of assimilation of practical skills - 38-40 (for a question valued at 40 points), 29-30 (for a question valued at 30 points);

- **"very good"**, the student has mastered the theoretical material well, has the main aspects from primary sources and recommended literature, presents it in a reasoned way; has practical skills, expresses his thoughts on certain problems - 34-37 (for a question valued at 40 points), 26-28 (for a question valued at 30 points);

- **"good"**, the student has mastered the theoretical material; has practical skills, expresses his thoughts on certain problems, but certain inaccuracies and errors are assumed in the logic of the presentation of theoretical content or in the analysis of practical material - 30-33 (for a question that is evaluated at 40 points), 23-25 (for a question valued at 30 points);

- **"satisfactory"**, the student has basically mastered the theoretical knowledge of the academic discipline, orients himself in primary sources and recommended literature, but answers unconvincingly, confuses concepts; when answering questions of a practical nature, reveals inaccuracies in knowledge - 26-29 (for a question valued at 40 points) 20-22 (for a question valued at 30 points);

- **"sufficient"**, the student has mastered the theoretical knowledge of the academic discipline, but the answers to the questions reflect uncertainty or lack of stable knowledge; when answering questions of a practical nature, he does not know how to evaluate facts and phenomena, connect them with future activities - 24-25 (for a question valued at 40 points) 18-19 (for a question valued at 30 points);

- **"unsatisfactory"**, the student has not mastered the educational material of the discipline, does not know scientific facts, definitions, hardly orients himself in primary sources and recommended literature, lacks scientific thinking, practical skills are not formed - 23-0 (for a question valued at 40 points) 17-0 (for a question worth 30 points).

3. The sum of points for the answers on the exam is transferred to the exam grade according to the table:

### Overall rating

Rating value	Rating
95 ... 100	excellent
85 ... 94	very good
75 ... 84	good
65 ... 74	satisfactorily
60 ... 64	sufficient
Less than 60	unsatisfactorily

4. The sum of points for the answers on the exam is converted to a 200-point scale according to the table:

The table of correspondence of the Rating System (RS 60...100) to the points of the 200-point scale (100...200)

Rating System Evaluation	Points 100...200	Rating System Evaluation	Points 100...200	Rating System Evaluation	Points 100...200	Rating System Evaluation	Points 100...200
60	100,0	70	125,0	80	150,0	90	175,0
61	102,5	71	127,5	81	152,5	91	177,5
62	105,0	72	130,0	82	155,0	92	180,0
63	107,5	73	132,5	83	157,5	93	182,5
64	110,0	74	135,0	84	160,0	94	185,0
65	112,5	75	137,5	85	162,5	95	187,5
66	115,0	76	140,0	86	165,0	96	190,0
67	117,5	77	142,5	87	167,5	97	192,5
68	120,0	78	145,0	88	170,0	98	195,0
69	122,5	79	147,5	89	172,5	99	197,5
						100	200,0

## V. EXAMPLE OF EXAMINATION CARD

Form No. H-5.05

National Technical University of Ukraine

"Igor Sikorsky Kyiv Polytechnic Institute"

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(full name of higher education institution)

Educational degree *doctor of philosophy*

Specialty *184 Mining*

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(name)

Academic discipline *Entrance exam*

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### EXAMINATION CARD № 1

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1. *Classify the methods of separating facing stone from massif*

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2. *Estimate the duration of transportation when the dragline is in operation*

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3. *Analyze blasting methods*

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Approved

Guarantor of the educational program

\_\_\_\_\_ Oksana VOVK

Kyiv 2022



## **PROGRAM DEVELOPERS:**

*Oksana Vovk, Doctor of Technical Sciences, Professor, Head of the  
Department of Geoengineering*

*Natalia Zueivska, Doctor of Technical Sciences, Professor, Professor of the  
Department of Geoengineering*



## **The program is recommended:**

Academic council of the Educational and Scientific Institute  
of Energy Saving and Energy Management

Head of the academic council  
protocol No. 05  
from December 29, 2022



Serhii DENYSIUK