Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Geoengineering

COMPUTER-AIDED DESIGN SYSTEMS

Work program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	***Second (master's)***
Field of knowledge	*18 Production and technology*
Speciality	*184 Mining*
Educational program	*Geoengineering*
Discipline status	*Normative*
Form of study	*full-time (full-time) / full-time (evening) / part-time / distance / mixed*
Year of preparation, semester	*I year, autumn semester*
Scope of discipline	*3.5 credits/105 hours (lectures – 18 hours, laboratory – 36 hours)*
Semester control/ control measures	*Credit, modular control work, calculation and graphic work.*
Schedule of classes	*http://roz.kpi.ua*
Language of instruction	*Ukrainian, English*
Information about course leader / teachers	*Lecturer: Doctor of Technical Sciences, Zuievska Natalia Valerievna, (+38)0509821770,znata1770@gmail.com* *Laboratory / Seminary Doctor of Technical Sciences, Zuievska Natalia Valerievna, (+38)0509821770, znata1770@gmail.com*
Course placement	

The program of the discipline

1. Description of the discipline, its purpose, subject of study and learning outcomes

In modern geo-construction, the problem of modeling real physical processes (engineering analysis – changes in the SRS of aboveground and underground building structures) occupies an important place and is characterized by a certain specificity in the use of the corresponding mathematical apparatus. That is why more and more attention is paid both theoretically and practically to the development and use of tools, techniques and technological complexes that accelerate the design process. Modern geotechnical systems of computer-aided design, which are the most widespread in Ukraine and are actively used in design organizations, are considered.

The purpose of the discipline is the formation of students' competencies:

- SK1. Ability to identify, set, solve problems and make informed decisions in professional activities;

- SK4. Ability to develop project documentation (terms of reference, technical proposals, draft design, technical design, working project) for mining and geo-construction systems;

- SK6. Ability to perform design work of special methods of construction, objects of mineral development, to take special measures for the reconstruction of underground structures and mining enterprises;

- SK7. Ability to implement the general principles of integrated optimization during project development.

1.2. The main tasks of the discipline.After mastering the discipline, students must demonstrate the following learning outcomes: knowledge:

- *РН6. Виявлять, ставити, вирішувати проблеми та приймати обґрунтовані рішення в*

професійній діяльності;

- PH9. Develop project documentation (terms of reference, technical proposals, preliminary design, technical project, working project) for mining and geo-construction systems;

- PH11. Carry out design work of special methods of construction, objects of mineral development, take special measures for the reconstruction of underground structures and mining enterprises;

- PH12. Implement the general principles of complex optimization during project development.

2. Pre-requisites and post-requisitions of disciplines (place in the structural and logical scheme of education according to the relevant educational program)

It is based on the study of normative educational components of the cycle of professional training of bachelors.

1. The content of the discipline

Section 1.

Topic 1.1.Introduction to the discipline. Course objectives and connection with other disciplines. Skills that a student must master. Thematic content of the course.

Section 2.

Topic 2.1 Computational METHODS OF CAD.

Topic 2.2. Numerical methods. Algebraic equations. Numerical integration.

Section 3 . Application of the finite element method.

Topic 3.1. Resampling a region, defining nodal points and elements.

Topic 3.2 Boundary problems of the finite element method.

Section 4 . Implementation of the finite element method in computer programs.

Topic 4.1. Mechanics of a deformed body. Theory of elasticity for geoengineering.

2. Learning materials and resources

Базова література:

1. *Прикладні аспекти використання геостатичних методів дослідження в гірництві [Електронний ресурс] : монографія / Зуєвська Н.В., Соболевський Р.В., Виноградова О.П., Горобчишин О.В. Електронні текстові дані (1 файл: 6,94 Мбайт). - КПІ ім. Ігоря Сікорського, 2019 р. – 150 с.*
2. *Ресурсозберігаючі технології при будівництві геотехнічних об'єктів// Зуєвська Н.В.,Вапнічна В.В., Зайченко С.В., Шайдецька Л.В./ [Електронний ресурс] монографія/ КПІ ім. Ігоря Сікорського, 2018 р. – 202 с. http://ela.kpi.ua/handle/123456789/22173*
3. *Зуєвська Н. В. Особливості врахування впливу будівельної техніки на стійкість конструкції котловану при щільній міській забудові / Н. В. Зуєвська, В. Є. Губашова, Л. В. Шайдецька // Збірник наукових праць Національного гірничого університету. - 2018. - № 54. - С. 170-183 . http://nbuv.gov.ua/UJRN/znpngu_2018_54_18.*
4. *Перспективи застосування струменево-цементаційного закріплення грунтових основ // Зуєвськаи Н.В.,Шайдецька Л.В, Губашова В.Є./Геоінженерія : науково-технічний жур-нал. – 2020. – Вип. 3. – С. 13–19 https://doi.org/10.20535/2707-2096.3.2020.219322*
5. *Стабілізація ґрунтового масиву за допомогою ін'єкційних анкерів. Порівняльний аналіз особливостей проектування // Зуєвська Н.В., Губашова В.Є./ Збірник наукових праць Національного гірничого університету "Дніпровска Політехника" Дніпро, 2020. №60-06. С. 58-68. https://doi.org/10.33271/crpnmu/60.058*

Додаткова література

1. *Моделювання підсилення ґрунтової основи складно-компонентними системами //Зуєвська Н.В., Губашова В.Є./ Вісті Донецького гірничого інституту. м. Покровськ, 2020. №1 (46). С. 36-44.*

2. *Вплив виконання елементів струменевої цементації на фізико-механічні характеристики навколишнього ґрунтового масиву. //Зуєвська Н.В., Шайдецька Л.В., Губашова В.Є./Науковий журнал "Енергетика: економія, технології, екологія". Київ, 2019. №4. С. 27-34 https://doi.org/10.20535/1813-5420.4.2019.200474*
3. *Системи автоматизованого проектування в будівництві : навчальний посібник /А. С. Моргун, В. М. Андрухов, М. М. Сорока,І. М. Меть. – Вінниця : ВНТУ, 2015. – 129 с. https://press.vntu.edu.ua/index.php/vntu/catalog/download/65/109/120-1?inline=1*
4. *Прикладні аспекти використання геостатичних методів дослідження в гірництві// Зуєвська Н.В., Соболевський Р.В.,Виноградова О.П.,Горобчишин О.В./ [Електронний ресурс] монографія/ КПІ ім. Ігоря Сікорського, 2019 р. – 152 с.*

Educational content

1. Methods of mastering the discipline (educational component)

To master the discipline, an explanatory, illustrative and reproductive teaching method is used.

Lectures

	Title of the lecture topic and list of main questions
Lecture 1	*Introduction to discipline. Course objectives and connection with other disciplines. Skills that a student must master. Thematic content of the course. Connection of the course with related disciplines.* *Tasks on the SRS. The possibility of using CAD for underground construction. Literature: [1] – pp. 30-32.*
Lecture 2	*Computational methods of CAD. Numerical methods. Algebraic equations. Numerical integration. Differential equations with initial conditions. Algorithms for numerical integration of systems of differential equations. Methods for solving systems of nonlinear algebraic equations. Finite element method.* *Tasks on the SRS. The basic concept of the method. Analyze the advantages and disadvantages of the method. [1] – pp. 34-38.*
Lecture 3	*Application of the finite element method. Resampling the area. Definition of nodal points and elements. Boundary problems of the finite element method. The equation of the method of finite elements.* *Tasks on the SRS. Types of finite elements. Splitting a marquee into items. Numbering nodes.[1] – pp. 38-41.*
Lecture 4	*Implementation of the finite element method in computer programs. Direct construction of the global rigidity matrix. A system of linear equations.* *Tasks on the SRS. A general flowchart of calculations. [1] – pp. 41-42. [4] – pp. 80-82.*
Lecture 5	*Mechanics of a deformed body. Theory of elasticity. One-dimensional case. Two-dimensional problems of the theory of elasticity. Three-dimensional problems of the theory of elasticity.* *Tasks on the SRS. Axisymmetric problems. [1] – P. 80-81, [2] – P. 67, [4] – P. 180-202.*
Lecture 6	*Methods for determining the stress-strain state of structures. SRS of building structures can be determined on the basis of two equivalent directions: local and integral. Energy (thermodynamic) method of studying natural phenomena.* *Tasks on the SRS. Static (equilibrium equation). Geometric equations of continuity. Physical equations. [1] – pp. 86-89, [2], [4].*
Lecture 7	*Construction of mechanical and mathematical analogues of geomechanics problems on the construction of model problems of geomechanics. Features of the construction of*

	boundary tasks of surface, near-surface and underground geomechanics. Systems of separate equations of geomechanics problems within elastic models; viscoelastic models; models of urugoplastic media. Systems of decisive equations of dynamic problems of mining mechanics of rocks and arrays.The use of other modern geotechnical programs, in particular, the program "Slide" in the choice of technologies for stabilizing slopes, hazardous areas. *Tasks on the SRS. Modeling of soil anchors to stabilize the wall in the ground [3], [4].*
Lecture 8	*Basic approaches to building computer models in geomechanics. Features of construction of computer models of problems of surface, near-surface and underground geomechanics. Construction of design schemes taking into account the large-scale factor (the size of underground structures and areas of the forged thickness). Construction of design schemes taking into account dynamic effects and time factor. Construction of design schemes, taking into account the formation of areas that are in different deformation states. Computer modeling of geomechanical processes in special zones (faults, macrocracks, mulds, substitution areas, etc.) Tasks on the SRS. Method of modeling injection piles in Plaxis. [3].*
Lecture 9	*Modern approaches and methods for solving mechanical and mathematical model problems of geomechanics in different formulations and approximations On the construction of model problems of geomechanics, taking into account the formation of areas that are in different deformation states. The effect of the formation of disintegration zones on the outskirts of underground structures. Modeling of zones of fissure, destruction anddistribution of macrocracks in the array with underground structures. Construction of model tasks with "non-classical laws of interconnection of the components of the stress-strain state" (block structure, descending branch of the deformation diagram, etc.).* *Tasks on the SRS. Modeling of traffic flow optimization during construction in dense urban development [2].*

Laboratory classes

	Назва теми заняття та перелік основних питань
Laboratory workshop 1	*Introduction to the Plaxis program. The purpose and composition of the program. Illustration of software. General modeling questions. The procedure of administration. Run the program.*
Laboratory workshop 2	*Enter general settings. The first step in each task is to set the basic parameters of the finite element model. General Settings window. These parameters include - the description of the task, the type of calculation, the main type of elements, the basic units and the size of the drawing field. When the general parameters task is completed, a drawing field appears with the beginning of the reference and the direction of the coordinate system. Entering a geometric contour.*
Laboratory workshop 3	*Basic rules for the introduction of boundary conditions. Boundary task rules, they can be selected from the Loads menu. To solve deformation problems, there are two types of boundary conditions: specified eliminations and loads. All boundaries must have one boundary condition in each direction. If a certain boundary condition (free border) is not set, then natural conditions apply, that is. the given load is zero and free displacement.*

Laboratory workshop 4	*The choice of soil model and its parameters. In Plaxis, soil characteristics are collected in datasets based on materials stored in the corresponding database. Selection of data from the program database for such structures as walls, plates, anchors, geogrids and others. Different types of designs have different parameters, and therefore different types of data sets. Plaxis differs in material datasets for Soil & Interfaces, Plates, Anchors, and Geogrids. Create a dataset based on materials after you enter boundary conditions.*
Laboratory workshop 5	*The choice of soil models and their parameters.*
Laboratory workshop 6	*Calculation of the ring foundation. Located on a sandy base. Rigid foundation. Flexible foundation.*
Laboratory workshop 7	*Modeling the excavation of the soil in the immediate vicinity of the river. Earthworks are being carried out for the construction of the tunnel. Modeling the construction of a pit that is flooded. Construction of a pit in watered conditions.*
Laboratory workshop 8	*Modeling the construction of a pit with the extraction of soil without the presence of water. The walls of the pit are strengthened with the help of soil anchors. Modeling of soil anchors taking into account the previous voltage. Calculation of groundwater filtration to build a new distribution of water pressure.*
Laboratory workshop 9	*The construction of the pit is dry using the "wall in the ground" method.*
Laboratory workshop 10	*River dam (dam) in untreated soils. Calculation of the stability of the dam, taking into account the impact on changes in the water level. Analysis of the influence of changes in pore pressure on the deformation and stability of geotechnical structures.*
Laboratory workshop 11	*Construction of a road embankment.*
Laboratory workshop 12	*Subsidence of the base during the construction of the tunnel. Modeling the construction of a shield tunnel in soils of medium strength. The construction of the shield tunnel is carried out by excavating the soil with a tunneling machine and arranging the processing of the tunnel behind it.*
Laboratory workshop 13	*The stability of the slaughter of the tunnel. The stability of the notch under the "wall in the ground."*
Laboratory workshop 14	*Bearing capacity of the bored pile. Simulation of the test of a drilled pile by load. Simulated field tests of 6 piles in diameter35-50 cm, to which both compressive and tensile loads were applied. Piles were installed in muddy and clay sands, which can be divided into several layers. The water level is immediately under the lower end of the pile.*
Laboratory workshop 15	*Construction of the pit. The construction of a pit in layers of plastic clay and peat is considered. Construction of the pit construction of groove walls in the weak soil described. A pit measuring 12 m by 14 m and a depth of 7.5 m. After the final extraction of the soil, an additional surface load is applied to one side of the pit.*
Laboratory workshop 16	*Bearing capacity of the pile, immersed in water-saturated soil. The bearing capacity of the marine base is considered. The submersible pile is a large-diameter steel shell with the upper end closed, which is immersed in the seabed by pumping water out of the pile cavity. The pressure drop inside and outside the pile creates a driving force that immerses the pile in the soil. The installation process itself will not be simulated. The*

	bearing capacity of the anchor after installation is considered. Three different angles of action of traction are considered.
Laboratory workshop 17	*Modeling of shear processes on slopes. Deformed model and isofield of slope deformations. Determination of the stability coefficient, slope fracture scheme and determination of the sliding surface.*
Laboratory workshop 18	*Using the Slide program to clarify the calculation of the stability coefficient and optimize the technology of strengthening shear areas of the slope.*

2. Independent work of the student / graduate student

Independent work of the student involves:

- *Preparation for classroom classes – 43 hours,*
- *Preparation for a modular test – 2 hours,*
- *Preparation for the test – 6 hours.*

	Questions for self-study
1	*Geomechanical processes of the phenomenon as mechanics.*
2	*Definition and classification of problems of geomechanics as problems of mechanics of continuous and discrete media.*
3	*Features, rules and approaches to the construction of model boundary problems of geomechanics. On the construction of model problems of geomechanics, taking into account the formation of areas that are in different deformation states.*
4	*The effect of the formation of disintegration zones in the vicinity of underground structures.*
5	*Approaches to modeling zones of fissure, destruction and distribution of macrocracks in rock massifs with underground structures. Features of computer modeling of geomechanical processes.*
6	*Features of building computer models of surface, near-surface and underground geomechanics .Basic approaches to the construction of computer models of geomechanics problems.*
7	*Construction of design schemes taking into account the large-scale factor (the size of underground structures and areas of the fake thickness).*
8	*Construction of design schemes, taking into account the formation of areas that are in different deformation states.*

Policy and control

1. Policy of the discipline (educational component)

The system of requirements that are put before the student:

At the time of each lesson provided by the working curriculum, the students from which it works must have Zoom installed (in the case of distance learning). At the first lesson of students, the teacher informs how the study of the material of classes, the implementation of laboratory work will be carried out. Provides all the necessary teaching materials through distance courses or Google Class.

During the course "CAD" students are obliged to adhere to the general moral principles and rules of ethical behavior specified in the Code of Honor of the National Technical University of Ukraine KPI. Igor Sikorsky. All students, without exception, must comply with the requirements of the Regulations on the system of prevention of academic plagiarism at the National Technical University of Ukraine KPI them. Igor Sikorsky.

For writing an article and publishing it in a professional edition, the student is awarded (10 points) incentives, preparation of abstracts for participation in conferences (5 points). The amount of incentive points should not exceed 10 points.

2. Types of control and rating system for evaluating learning outcomes (RSO)

Current control. *Laboratory practice involves the implementation of 9 practical tasks of 5 points each, two MKR (conducted directly in a practical lesson in the presence of a teacher, 15 points each) and RGR which is estimated at 25 points.*

MKR consists of test tasks of two levels of complexity. The first difficulty level contains 6 questions, each of which offers several answers, only one correct one. Each correct answer is estimated at 1 point. The second level of complexity aims to test knowledge on the use of certain design schemes (structures) and involves providing the correct answer based on the results of working with a graphic image. This level contains three tasks, each of which is estimated at 3 points.

Calendar control. *It is held twice a semester as a monitoring of the current state of fulfillment of the conditions of the syllabus. The condition for positive first and second calendar control is to receive at least 50% of the maximum possible rating at the time of the relevant calendar control.*

Semester control. *Passed. Conditions of admission to semester control: completed and credited MKR and practical work, RGR, and a starting rating of at least 60 points. The maximum possible starting rating of a student should be 100 points.*

The sum of the starting points is transferred to the scoring according to the table:Table of compliance of rating points with scores on a university scale:

Score	*Score*
100-95	*Perfectly*
94-85	*Very good*
84-75	*Well*
74-65	*Satisfactory*
64-60	*Enough*
Less than 60	*Disappointing*
Conditions of admission have not been met	*Not allowed*

3. Additional information on the discipline (educational component)

List of those that are submitted for semester control

1. *Definition and classification of problems of geomechanics as problems of mechanics of continuous and discrete media.*
2. *Definition and description of the combined tasks of geomechanics (tasks of hydrogeomechanics, gas geomechanics).*
3. *Features, rules and approaches to the construction of model boundary problems of geomechanics*
4. *Systems of solving equations of geomechanics problems within elastic models.*
5. *Systems of solving equations of geomechanics problems within viscoelastic models.*
6. *Systems of solving equations of geomechanics problems within models of elastic media.*
7. *Systems of solving equations of dynamic problems of mechanics of rocks and arrays.*
8. *On the construction of model problems of geomechanics, taking into account the formation of areas that are in different deformation states.*
9. *The effect of the formation of disintegration zones in the vicinity of underground structures.*
10. *Approaches to modeling zones of fissure, destruction and distribution of macrocracks in rock massifs with underground structures.*
11. *Features of computer modeling of geomechanical processes. Features of building computer models of surface, near-surface and underground geomechanics.*
12. *Basic approaches to the construction of computer models of geomechanics problems. Construction of design schemes taking into account the large-scale factor (the size of underground structures and areas of the fake thickness).*
13. *Construction of design schemes, taking into account the formation of areas that are in different deformation states.*
14. *Computer modeling of geomechanical processes on landslide areas.*

The work program of the discipline (syllabus):
Compiled by Professor, Doctor of Technical Sciences, Zuievska N.V.
Approved by the Department of Geoengineering (protocol No ___ of _____)
Approved by the Methodical Commission of the SR IEE (Protocol No. 12 of 24.06.2022)