National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Department of Geoengineering

Optimization of mineral resources extraction processes in the quarry

Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	*Second (master's)*
Branch of knowledge	*18 Production and technologies*
Specialty	*184 Mining*
Educational program	*Geoengineering*
Discipline status	*Selective*
Form of education	*Intramural (daytime)*
Year of training, semester	*1st year, spring semester*
Scope of the discipline	*4 ECTS credits*
Semester control/control measures	*Credit*
Lessons schedule	*http://rozklad.kpi.ua/*
Language of teaching	*English*
Information about head of the course/ teachers	*Lecturer: Doctor of Technical Sciences, Professor, Tkachuk Kostyantyn Kostyantynovich, kkttkk297@gmail.com* *Practical training: Doctor of Technical Sciences, Professor, Tkachuk Kostyantyn Kostyantynovich, kkttkk297@gmail.com*
Placement of the course	*Google Classroom (Google G Suite for Education, domain LLL.kpi.ua, platform Sikorsky-distance); access by invitation of the teacher*

Program of educational discipline

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

During the study of the discipline, students develop engineering knowledge about the processes of extracting mineral resources in a quarry, energy costs during excavation of a rock mass, the influence of lumpiness of rock on energy costs during excavation. Calculation of the productivity of the process of digging and excavation work in general for excavators of the power shovel type.

The optimization of mineral resources extraction processes in the quarry is aimed at studying the regularities and dependencies of the process of digging with a power shovel type excavator using models and taking into account the dynamics of soil resistance.

Learning results

– *To ensure the complete preservation of the subsoil and extraction of minerals.*

– *Develop measures to select the technological parameters of the excavator face and the mode of operation of the excavator.*

– *Calculation of the variable operational productivity of excavators of the power shovel type and establishment of rational modes of their operation.*

– *Optimizing the productivity of excavators in the quarry according to the criterion of energy intensity.*

To use the acquired knowledge on the optimization of mineral resources extraction processes in the quarry to increase the technical, economic and environmental efficiency of the mining enterprise, to ensure the saving of electricity during the operation of the excavator in the optimal mode.

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

Before starting the study of the discipline "Optimization of mineral resources extraction processes in the quarry", the student must be familiar with geomechanics, the current state of mining operations taking into account the properties of rocks, organizational, technical and technological conditions at the mining enterprise, as well as the state of energy costs when excavating rock mass in quarries.

3. Content of the academic discipline

1 PURPOSE AND OBJECTIVES OF THE DISCIPLINE

Assessment of the current state of excavation works taking into account the properties of rocks, organizational, technical and technological conditions in quarries. The state of energy costs during the excavation of rock mass in quarries. Models and methods of calculating the productivity of the digging process and excavation work in general for excavators of the power shovel type. Methods and criteria for optimization of excavation works in quarries.

2 REGULARITIES AND DEPENDENCES OF THE DIGGING PROCESS WITH EXCAVATOR OF THE POWER SHOVEL TYPE USING MODELS AND TAKING INTO ACCOUNT THE DYNAMICS OF SOIL RESISTANCE

Justification of indicators of the process of digging rocks with an excavator and its features. Forces acting during digging. The influence of the speed of digging on the resistance of rock to digging. Mathematical modeling of the digging process of a power shovel type excavator. Existing methods of calculating the productivity of a power shovel type excavator. Optimization of the digging process of the excavator according to the criterion of minimum energy consumption.

3. MATHEMATICAL MODELS OF THE EXCAVATOR USE PROCESS OVER TIME

Regularities of the formation of the coefficient of use of the excavator over time. Mathematical model of precinct technological interruptions and machine time failures (first subsystem). Mathematical model of the subsystem of organizational interruptions and precinct failures on calendar time (the second subsystem). Mathematical model of the subsystem of general career failures of equipment (the third subsystem). Mathematical model of the coefficient of use of the excavator over time of the system « excavation bottom».

4. FORMATION OF THE VARIABLE OPERATIONAL PRODUCTIVITY OF THE EXCAVATOR ON THE BLOCK AND ITS OPTIMIZATION ACCORDING TO THE CRITERION OF MINIMUM ENERGY CAPACITY

Current methods of calculating the variable operational productivity of a power shovel type excavator and their analysis. The influence of fluctuations and restrictions on digging productivity and the coefficient of use of the excavator over time. The law and the main parameters of the probability distribution of the operating productivity of the excavator per shift. Optimizing the productivity of excavators in the quarry according to the criterion of energy intensity. Modes of operation of the excavator when optimizing the parameters of the excavation process in the quarry. Local optimal mode of operation of the excavator.

4. Educational materials and resources

Literature

1. *Abhay Soni. Mining Techniques: Past, Present and Future. London: Intechopen Limited. 2021. 178 p.*
2. *NPCS Board of Consultants & Engineers. The Complete Technology Book on Minerals and Mineral Processing. Delhi: Asia Pacific Business Press Inc. 2007. 696 p.*
3. *G. Pivnyak, V. Bondarenko, I. Kovalevs'ka, M. Illiashov. Geomechanical Processes during Underground Mining: School of Underground Mining. London: CRC Press. 2012. 300 p.*

Educational content

5. Methods of mastering an educational discipline (educational component)

Lecture classes

№	*The name of the topic of the lecture and a list of main questions*
Lecture 1	*Assessment of the current state of excavation works taking into account the properties of rocks, organizational, technical and technological conditions in quarries. General information about the development of research in the field of opencast mining of mineral deposits. The state of energy costs during the excavation of rock mass in quarries. Analysis of the excavation process of overburden mining and auxiliary works.*
Lecture 2	*Influence of lumpiness of rock on energy consumption during excavation. Models and methods of calculating the productivity of the digging process and excavation work in general for excavators of the power shovel type.*
Lecture 3	*Optimization of the digging process of the excavator according to the criterion of minimum energy consumption.*
Lecture 4	*Justification of indicators of the process of digging rocks with an excavator and its features. Forces acting during digging.*
Lecture 5	*The influence of the speed of digging on the resistance of rock to digging. Mathematical modeling of the digging process of a power shovel type excavator.*
Lecture 6	*Existing methods of calculating the productivity of a power shovel type excavator. Optimization of the digging process of the excavator according to the criterion of minimum energy consumption.*
Lecture 7	*Regularities of the formation of the coefficient of use of the excavator over time.*
Lecture 8	*Mathematical model of precinct technological interruptions and machine time failures (first subsystem).*
Lecture 9	*Mathematical model of the subsystem of organizational interruptions and precinct failures on calendar time (the second subsystem).*
Lecture 10	*Mathematical model of the subsystem of general career failures of equipment (the third subsystem).*
Lecture 11	*Mathematical model of the coefficient of use of the excavator in the time of the system «excavation bottom».*
Lecture 12	*Current methods of calculating the variable operational productivity of a power shovel type excavator and their analysis. The influence of fluctuations and restrictions on digging productivity and the coefficient of use of the excavator over time.*
Lecture 13	*The law and the main parameters of the probability distribution of the operating productivity of the excavator per shift. Modes of operation of the excavator when optimizing the parameters of the excavation process in the quarry. Local optimal mode of operation of the excavator.*

Practical training

№	*Tasks that are assigned to practical classes*
Practical lesson 1	*Soil cutting force*
Practical lesson 2	*The force to overcome the drag prism resistance*
Practical lesson 3	*The force to overcome the resistance of filling the bucket*
Practical lesson 4	*Dependence of soil cutting force on cutting speed*
Practical lessons 5, 6	*Calculation of the technical productivity of digging (scooping) of the excavator*
Practical lessons 7, 8	*Calculation of the utilization rate of an EQC type excavator over time*
Practical lesson 9	*Calculation of operational variable productivity of the EQC type excavator*

Information is provided (by sections, topics) about all educational classes (lectures, practical, seminar, laboratory) and recommendations for their assimilation are provided (for example, in the form of a calendar plan or a detailed description of each class and planned work).

6. Independent work of a student/graduate student

The student's independent work involves:

preparation for classroom classes - 4 hours;

preparation for the modular control work - 2 hours;

The types of independent work (preparation for classroom classes, calculations based on primary data obtained in laboratory classes, solving tasks, writing an abstract, performing calculation work, performing homework control work, etc.) and the time allotted for this are indicated.

Policy and control

7. Policy of academic discipline (educational component)

Attending classes

Attendance or absence from lectures is not evaluated. However, students are encouraged to attend classes, as they teach theoretical material and develop the skills needed to complete the semester's individual assignment.

Attending practical classes is highly desirable, as typical engineering problems are solved at these classes, which are taken for credit. Students also have the opportunity to consult with the teacher on all issues related to the discipline.

Attendance of modular control works is mandatory. If a student missed the MCW for good reasons, for example, due to health, then if he has a supporting document (certificate), he can write the missed test within a week. Otherwise, the MCW is not evaluated. It is not possible to retake the test for a higher grade.

The procedure for contesting the results of control measures

Students have the opportunity to raise any issue relating to the screening process and expect it to be dealt with in accordance with pre-defined procedures. Students have the right to appeal the results of the control measures, but must explain with reasons which criterion they do not agree with according to the evaluation letter and/or remarks.

Academic integrity

The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code

Norms of ethical behavior

Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine " Igor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code

8. Types of control and rating system for evaluating learning results (RSE)

Practical tasks (r_1)

You need to complete 9 practical tasks in total. The weighted score of one practical task is 4 points. The minimum number of points that must be scored in order for the practical task to be considered passed is 3.6 points. The maximum number of points for all practical tasks: r1=6 points x 9 = 54 points. (Table 1)

Rating points for the defense of the practical task

Table 1

Points	Evaluation criterion
6,0	There are no comments on the report, there are answers to all questions
5,4	Minor comments on the report, answers to most questions
4,8	Remarks on the obtained results, answers to part of the questions
4,2	The report has errors, answers only to certain questions
3,6	The work is done, the correct results are obtained, but not protected
0,0	The work has not been completed, the report has not been submitted

Control works (r2)

One control work consists of three tasks.

The weighted score of one control work is 23.

Evaluation of the control work is carried out in accordance with table 2.

The maximum number of points for two control works, respectively, is:

r2=23 points x 2 = 46 points.

Rating points for the control work

Table 2

Points	Evaluation criterion
23	Correct answer to more than 90% of questions
20,7	Correct answer to 90% of questions
18,4	Correct answer to 80% of questions
16,1	Correct answer to 70% of questions
13,8	Correct answer to 60% of questions
0	Correct answer for less than 60% of the questions or the student was absent

Penalty and incentive points

The overall rating for the discipline includes penalty and incentive points (Table 3), which are added or subtracted from the sum of the weighted points of all control measures. The total amount of penalty points cannot exceed 60 × 0,1 = (-6) points. The total amount of incentive points cannot exceed 60 × 0,1 = (+6) points.

Table 3

Action	Points
Untimely presentation of the results of the practical session	minus 1 point (but in total no more than minus 6)
Application of an original approach to solving problems	plus 1 point

Conditions of final attestation

In order to receive a “pass” from the first final assessment, the student must complete all practical work according to the schedule. To receive a “pass” from the second final assessment, the student must have at least 18 points (provided that at the beginning of the 14th week according to the calendar activities, a student can get a maximum of 35 points).

Credit assessment criteria

The rating evaluation system consists of points received by the student based on the results of current control measures, incentive and penalty points. The rating is given to the students in the penultimate lesson of the discipline in the semester.

Applicants who have fulfilled all the conditions for admission to the credit and have a rating of 60 or more points receive a rating in accordance with the received rating without additional tests (Fig. 1).

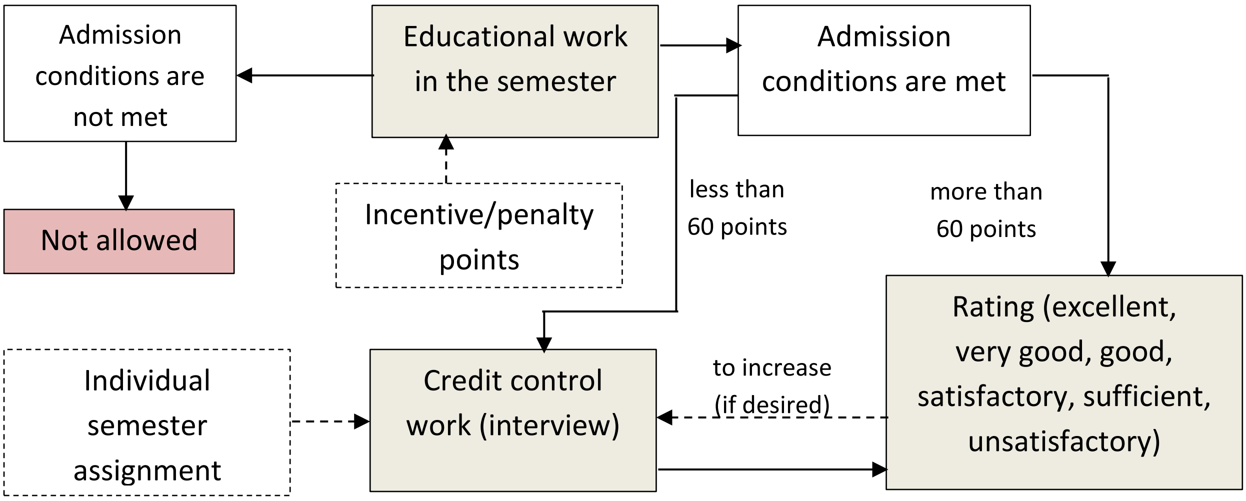

Figure 1 – Block diagram of the functioning of the RSO in the discipline

With students who have fulfilled all the admission requirements and have a rating score of less than 60 points, as well as with those students who wish to improve their rating score, the teacher conducts a semester control in the form of a credit control work in the last lesson of the discipline in the semester.

In this case, the points obtained for the individual work remain, and the points obtained for the modular control works are canceled.

Credit is conducted in the form of an oral interview or a credit assignment. The credit assignment consists of five questions. Each question is rated at a maximum of 10 points. The maximum number of points received for the credit control work is 50 points:

$$r4=9.2 \text{ points} \times 5 \text{ questions} = 46 \text{ points.}$$

The credit evaluation criterion is defined as the sum of the quality of the answers to each task of the ticket according to the table. 4.

Table 4

Number of points for one ticket task

Points	Evaluation criterion
9.2	An excellent answer (at least 95% information), minor remarks and inaccuracies are possible
8,3	Very good answer (at least 85% information), no mistakes, answer to the vast majority of questions, creative thinking
7,4	Good answer (at least 75% information), no mistakes, answers to most questions, some shortcomings
6,4	Sufficient answer (at least 60% of information), there are remarks, answer to only part of the questions
5,5	Satisfactory answer (at least 60% of information), significant errors, answer to individual questions, cannot explain the results
0	The answer is incorrect or less than 60% of the information, or it is missing

Calculation of the rating scale for the discipline

1. According to the results of current control measures for discipline, incentive and penalty points without credit control work:

$$R = r1+r2 = 54+ (23+23) = 100 \text{ points}$$

2. According to the results of current control measures for discipline, incentive and penalty points with credit control work:

$$R = r1+ r4 = 54+46 = 100 \text{ points}$$

In order to receive an appropriate grade in the discipline, the student must score a certain number of points, according to the calculation table (Table 5).

Table 5

Table of conversion of rating points into grades

Rating evaluation of the student	University scale of assessments of the level of acquired competences
95 … 100	Excellent
85 … 94	Very good
75 … 84	Good
65 … 74	Satisfactorily
60 … 64	Sufficiently
Less than 60 points	Unsatisfactorily
The conditions for admission to the semester control have not been met	Not allowed

9. Additional information on the discipline (educational component)

- *a list of questions submitted for semester control (for example, as an appendix to the syllabus);*
- *the possibility of enrolling certificates of completion of remote or online courses on the relevant subject;*
- *other information for students/graduate students regarding the peculiarities of mastering the academic discipline.*

Working program of the academic discipline (syllabus):

Written Doctor of Technical Sciences, Professor Tkachuk Kostyantyn Kostyantynovich

Approved by the department ___________ (protocol № ___ from _____________)

Agreed by the Faculty's Methodical Commission[1] (protocol № ___ from _____________)

[1] Methodical council of the university - for general university disciplines.