MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

Syllabus
of the academic discipline

"OPERATIONS RESEARCH"

for full-time students
of the training direction
6.030601 "Management"

Харків. Вид. ХНЕУ, 2013

Затверджено на засіданні кафедри економіки, організації та планування діяльності підприємств.

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The content of the academic discipline according to its modules and themes, as well as plans of lectures and practical training, questions to revise knowledge and system of students' knowledge evaluation are presented.

It is recommended for full-time students of the training direction 6.030601 "Management".

Вміщено зміст навчальної дисципліни за модулями й темами, а також плани лекцій і практичних занять, питання для закріплення знань та систему оцінювання знань студентів.

Рекомендовано для студентів напряму підготовки 6.030601 "Менеджмент" денної форми навчання.

Introduction

Efficiency growth is closely linked with quantitative reasoning of decision-making. Due to this, a specialist in management should know and be able to put into practice the economic and mathematical methods and models of operations research.

Future managers must also know the characteristics of the economy, organization and planning, using methods of operations research for better decision-making.

Academic discipline "Operations Research" refers to the cycle of regulatory subjects for students of the training direction "Management".

The purpose of the discipline is to master theoretical knowledge and practical skills in specialized mathematical economic methods to provide optimization of management, organization and planning tasks.

The task of the discipline is to apply operations research to test economic theories by means of economic-mathematical methods and quantitative substantiation of optimal solutions.

The topics of the subject are models and methods of system analysis, research methods and streamlining operations.

"Operations Research" is taught after the discipline "Higher and Applied Mathematics". It links the disciplines of mathematical cycle of economic sciences, prior to the study of professional subjects which are the basis for economic research.

The discipline training consists of lectures, laboratory studies, self-study work.

"Operations research" is taught within the training direction 6.030601 "Management" for full-time students.

The structure of the academic discipline "Operations Research" is given in Table 1.

Table 1

Structure of the academic discipline "Operations Research"

1	2	3
Academic discipline: Bachelors	The subject area, the direction of training, educational level	Discipline characteristics

The End of Table 1

1	2	3
The number of credits corresponding to ECTS – 2,5; including: semantic modules – 1; independent work	Code and name of the subject area: 0306 "Management and Administration"	Educational qualification – Bachelor. Year of study – the 2nd; the term – the 4th
Number of hours: total – 90	Training direction: 6.030601 "Management"	Lectures – 16 hours. Laboratory studies – 18 hours. Self-study – 56 hours
Number of weeks for training: 17. Number of hours per week – 2	Educational qualification – Bachelor	Form of control: test

1. Qualification requirements for students

The academic discipline "Operations Research" is based on knowledge obtained by students after the disciplines of economic and mathematical cycles: "Economics", "Macroeconomics", "Higher and Applied Mathematics" "Statistics" and others.

General knowledge and skills, acquired by students of the academic discipline "Operations Research", can be expanded in the process of learning subjects in the speciality.

During the study students receive the necessary knowledge at lectures and practical training and, performing individual tasks. Independent work of students is of great importance in the process of learning and consolidation of knowledge.

After studying the subject students should have competences in:

system analysis;

grid methods;

principles of grid model;

method of solving grid model;

practice of grid methods;

models of optimal planning;

practice of planning techniques;
the method of queuing;
method of solving queuing models;
application of queuing;
statistical quality control;
application of statistical quality control;
gaming models and their application;
the method of justifying the size of reserves;
basic principles of systems using mathematical functions;
chain planning methods;
constructing chain models;
calculating the critical path;
constructing mathematical model of optimal scheduling;
applying the model of optimal planning;
applying the methods of solving queuing;
the basic parameters of queuing;
calculation the parameters of statistical quality control;
building a system of incentives by mathematical functions;
calculation the optimal size of the stock of goods.

The descriptors levels of the National Qualifications Framework are presented in Table 2.

Table 2

Qualifications framework

Knowledge	Skill	Autonomy and Responsibility	Sociability
General principles of operations research studies	Essence of system analysis	Development and implementation of an enterprise analysis using methods of operations research	Introduction of operations research methods into practice
main stages in the study of specific economic situation	using applications during the development-accounts on PC	identification problems of operations research	providing system analysis results in an accessible form

2. Thematic plan of the discipline

Before studying this discipline the student should consider the application of the discipline, forms of educational process, the themes of lectures, laboratory studies, independent work, scope and structure of the training module, control types and methods of evaluating training.

Educational process is carried out in such formsas as lectures and laboratory studies, performance of individual assignments, independent work and current control.

The discipline "Operations Research" has 1 training module (Table 3).

Table 3

The structure of the educational discipline test credit

Theme	Number of hours:		
	Lectures	Laboratory studies	Self-study work
1	2	3	4
Semantic module. Economic-mathematical methods of operations research			
Theme 1. Subject and problems of operations research, methods of economic-mathematical modelling	2	0	5
Theme 2. Objectives and methods of queuing	2	10	5
Theme 3. Statistical methods for quality control	2	0	6
Theme 4. The tasks of organizing and coordinating	2	0	7
Theme 5. Network of planning and management methods	2	6	7
Theme 6. Optimization tasks of inventory management	2	2	7
Theme 7. Objectives and models of optimum resource allocation and replacement	2	0	7

The End of Table 3

1	2	3	4
Theme 8. Multicriteria problems in management	1	0	6
Theme 9. Problems under uncertainty and conflict	1	0	6
Total for module	16	18	56

3. Contents of the discipline in modules and themes

Semantic module. Economic-mathematical methods of operations research

Theme 1. Subject and problems of operations research, methods of economic-mathematical modelling

Subject of the course, its problems. Basic concepts: operations, equipment, strategy, operations factors, the criterion of efficiency. Characteristics of the production processes. System analysis. Simulation as a method of learning. The essence of modelling. The methods of making models (black and white boxes) simulation. Mathematical model of operations research. Stages of the model construction. Description of operations research models. Methods of Operations Research: queuing theory, statistical quality control, mathematical methods of optimal planning; Network of planning and management methods, gaming operations models, models of inventory management.

Application of operations research in modern conditions.

Theme 2. Objectives and methods of queuing

Production process as a process of care. The essence of the queuing problem.

Basic concepts of queuing theory: requirements, input flow requirements, phase requirements Feeds service output stream requirements. Characteristics of queuing models: Poisson, normal, exponential law distribution service time requirements.

Classification of queuing systems: system failures, system expectations.

Methods of problem solving: analytical method and statistical tests. Calculation of the queuing system: a simple request turns ratios, simple service channels. Analysis of quantitative estimates queuing system with limited and unlimited queue. Analysis of the costs arising in queuing system. Method of determining the optimal number of service channels.

Application of queuing in the modern world.

Theme 3. Statistical methods for quality control

The problem of quality and ways to resolve it. Statistical analysis of the accuracy of the process.

Analysis steps. Evaluation of the distribution of the parts size. Normal distribution and its properties that are used in the statistical analysis of product quality. Coefficient of precision machining and shear rate.

Statistical quality control. Calculation of statistical quality control: producer and consumer risks, value sample and width of control limits. Construction of control charts.

The practice of statistical quality controls in modern terms.

Theme 4. The tasks of organizing and coordinating

The essence of the theory of graphs. Basic concepts: elements, top, chain. Characteristics graphs.

The use of graph theory: the problem of organizing and coordination. The problem of building models and solution methods.

Theme 5. Network of planning and management methods

Essence grid methods of planning and management (SPU). Basic concepts: the event, the work path, the critical path. Principles of grid model.

Characteristics of deterministic and stochastic models. Addressing grid model. Analytical and matrix methods.

Construction of the line graphics performance and the chart of workers' needs. Optimizing grid model. How to optimize your network diagram on the criterion of time: with consideration of resources and without it.

Application of grid patterns in modern terms. Managing complex technical work on pre-production through network diagram.

Theme 6. Optimization tasks inventory management

The main problem of stocks justification. Classification of costs for the creation and storage of inventory. Basic theory of inventory management.

Problem of current stocks optimization under different conditions of the supplier. Statistical models of deterministic optimization of resources with and without a deficit.

Calculation of economic volume shipments of losses on stock holdings, ground fine for the deficit.

Static methods of inventory management. Using statistical modelling to identify sets of optional deliveries.

The practice of using inventory management models.

Theme 7. Objectives and models of optimum resource allocation and replacement

Characterization techniques of planning. Types of mathematical programming models: linear, stochastic, dynamic. Building a model of linear programming. Methods for solving problems of optimal planning. Algorithms for solving the problems of optimal planning.

Practical Applications of mathematical programming.

Assignment problem: formulation, the model solution method.

The problem of the production program optimization: formalization of production conditions, restrictions on supply of goods and services, optimality criteria, analysis of optimal plans.

Problems of optimal enterprise development, distribution of investment resources.

The essence of the replacement problem. Problem, solution methods. Dynamic model replacement.

Theme 8. Multicriteria problems in management

Characterization of multicriteria problems. Solution of such problems.

Methods to optimize management decisions multicriteria problems. Identifying alternative optimal plans.

Input-output: cost model, evaluation of technological coefficients matrix evaluation decision.

The practice of solving multicriteria problems in production. Selection and substantiation performance incentives. Using mathematical functions for building systems to encourage workers.

Methods of the incentives scale based on mathematical functions. The use of mathematical functions at industrial enterprises.

Theme 9. Problems under uncertainty and conflict

Characterization of stochastic programming problems.

Basic concepts of game theory. Selection strategy. Definition of the term "game". Variety of game models. Methods of finding the optimal strategy. Application of game models in modern terms: justification of proportions production with profit depending on demand.

4. Plans of lectures

Semantic module. Economic-mathematical methods of operations research

Theme 1. Subject and problems of operations research, methods of economic-mathematical modelling

1.1. Basic concepts, object and tasks of operations research.

1.2. The system and its properties.

1.3. Phases of operations research.

1.4. Methods of economic and mathematical modelling. Mathematical model of operations research.

1.5. Using the methods of operations research in modern conditions.

References: main [1; 2]; ancillary [6; 7].

Theme 2. Objectives and methods of queuing

2.1. The essence and the basic concepts of queuing.

2.2. Mathematical model of queuing.

2.3. Methods of queuing models. Statistical methods.

2.4. Analytical methods.

2.5. The use of methods of queuing.

References: main [1; 3]; ancillary [6; 7].

Theme 3. Statistical methods for quality control

3.1. The essence of statistical quality control.

3.2. Justification of statistical quality control parameters.

3.3. The use of statistical methods of quality control.

References: main [2; 3]; ancillary [6; 7].

Theme 4. The tasks of organizing and coordination

4.1. Basic concepts of graph theory.

4.2. Objectives arrangement and coordination.

References: main [1; 2; 3]; ancillary [6; 7].

Theme 5. Methods of planning and management

5.1. The essence of planning and management methods and their basic concepts.

5.2. Grid model.

5.3. Grid model decisions.

5.4. Optimizing grid model.

References: main [1; 2; 3]; ancillary [6; 7].

Theme 6. Optimization tasks of inventory management

6.1. Justification of lot deliveries optimal plan.

6.2. Industrial supplies models.

6.3. Other models of supply.

References: main [2; 3]; ancillary [6; 7].

Theme 7. Objectives and models of optimum resource allocation and replacement

7.1. Characterization of planning techniques.

7.2. Mathematical model of linear programming.

7.3. Methods for solving linear programming models.

7.4. The main problem solved by means of optimal programming.

References: main [1; 2; 3]; ancillary [6; 7].

Theme 8. Multicriteria problems in management

8.1. Features of multicriteria problems, solution methods.

8.2. Mathematical functions stimulation.

References: main [2; 3]; ancillary [6; 7].

Theme 9. Problems under uncertainty and conflict

9.1. Characterization of stochastic programming problems.

9.2. The theory of games.

9.3. Practical applications.

References: main [2; 3]; ancillary [6; 7].

5. Plans of laboratory studies

Themes of laboratory studies. Laboratory studies are a form of academic classes, where students are organized for a detailed analysis of some theoretical discipline. For this purpose objectives and guidelines for their implementation are given. Successful problem solving requires the use of batch programs.

During laboratory studies the students form skills of operation research methods application for solving specific economic problems. At laboratory studies each student performs individual tasks. For their successful performance the previous lecture material on a particular theme must be revised and used. Program Excel is used.

Three practical problems are presented:

1. theme 2 " Objectives and methods of queuing ";
2. theme 5 " Methods of planning and management";
3. theme 6 " Optimization tasks of inventory management".

The list of laboratory studies is presented in Table 4.

6. Self-study work of students

For successful learning of the subject it is necessary to conduct self-study work of students in the form of lectures, preparation for practical seminars, performance of individual tasks.

Table 5 lists the questions for self-study work.

Table 4

List of themes for modules of laboratory studies

Task	Themes	Hours	References
Semantic module. Economic-mathematical methods of operations research			
Task 1. Justification of size adjusters using queuing theory	Workshop 1. Build a model of equipment maintenance	2	References: main: [2; 3; 4]; ancillary: [6; 7]
	Workshop 2. Build a model of the equipment	2	References: main: [1; 3; 4]; ancillary: [6; 7]
	Workshop 3. Construct a numerical model of equipment maintenance	2	References: main: [2; 3; 4]; ancillary: [6; 7]
	Workshop 4. Construct a graphical model of service	2	References: main: [3; 4]; ancillary: [6; 7]
	Workshop 5. Calculating the cost of work time for repairing and service. Substantiate the number of adjusters	2	References: main: [3; 4]; ancillary: [6; 7]
Task 2. Justification of complexity. Conceptual design	Workshop 6. Build a network model for project development	2	References: main: [1; 3; 4]; ancillary: [6; 7]
	Workshop 7. Solve the network model	2	References: main: [2; 3; 4]; ancillary: [6; 7]
	Workshop 8. Construct a line graph chart of project development needs of workers	2	References: main: [2; 3; 4]; ancillary: [6; 7]
Task 3. To substantiate the order quantity	Workshop 9. Substantiate the amount of parts, and beverages	2	References: main: [3; 4]; ancillary: [6; 7]
Total		18	

Table 5

List of questions for self-study

Theme title	Question for independent work	References
Semantic module. Economic-mathematical methods of operations research		
1. Subject and problems of operations research, methods of economic-mathematical modelling	1. Production of a complex system. 2. Simulation as a method for economic processes	References: main: [2; 3; 4]; ancillary: [6; 7]
4. The tasks of organizing and coordinating	1. Combinatorial problems on graphs. 2. Assignment problem. 3. Salesman problem	References: main: [1; 3; 4]; ancillary: [6; 7]
7. Objectives and models of optimum resource allo-cation and replacement	1. Methods for solving problems of mathematical programming. 2. Features of static and dynamic models. 3. Optimization of an enterprise. 4. Distribution of investments as a problem of linear programming	References: main: [2; 3; 4]; ancillary: [6; 7]
8. Multicriteria problems in management	1. Game model. 2. Solving problems of uncertainty and conflict	References: main: [3; 4]; ancillary: [6; 7]
9. Problems of uncertainty and conflict	1. Input-output tables. 2. Method of matrix model. 3. Assessment of technological matrix	References: main: [3; 4]; ancillary: [6; 7]

7. Test questions for self-study

1. Explain the aims and objectives of the discipline "Operations Research".

2. Define the subject and object of the discipline "Operations Research"?

3. What are the methods of operations research?

4. Define the concept of a system.

5. Describe the basic properties of the system.

6. What are the main stages of the economic problems solution using economic and mathematical methods.

7. Advantages and disadvantages of modelling method.

8. What is a mathematical model of the operations?

9. Description of operations research models.

10. Stages of mathematical models construction of operations research.

11. The main problem of using operations research methods.

12. Basic concepts of queuing theory.

13. Basic laws of economic indicators distribution.

14. Integral and differential distribution function.

15. Histogram and polygon distribution.

16. Performance evaluation of the distribution choice.

17. Cumulates and their use in queuing.

18. Methods for solving queuing.

19. Monte Carlo method, its nature and use.

20. Random numbers and their use in queuing.

21. Numerical and graphical models. Basic principles of their construction.

22. Calculation criteria for choosing optimal variant of queuing.

23. Application of queuing.

24. The essence of the SPU.

25. Concepts of the SPU.

26. Principles of grid models.

27. Characterization of events.

28. Description of work.

29. Optimizing grid models.

30. Construction of the line graphics performance charts and manpower requirements.

31. Basic principles of optimizing grid model.
32. The practice of grid planning methods.
33. The essence of statistical quality control.
34. What is the precision?
35. What is the width of the control limits and the sample size?
36. What are the risks of a producer and a consumer?
37. How to measure risks of a producer and a consumer?
38. What is a control chart?
39. Name the basic principles of the control chart.
40. The practice of statistical quality control.
41. Basic concepts of inventory management system.
42. The main objective of inventory management.
43. What is the criterion for optimality in problems of inventory management?
44. Characterize the model of Wilson.
45. List the major costs associated with the formation of reserves.
46. Describe the model of industrial supplies.
47. Name the main features of the stochastic model in inventory management.
48. The method of optimal planning.
49. Describe the mathematical model of optimal scheduling.
50. Characterize methods for solving models of optimal planning.
51. The main features of the simplex method.
52. What is optimal for each iteration of the simplex table?
53. Methods of solving the problems of optimal planning.
54. Is it possible to have an optimal plan of artificial variables?
55. Is it possible to have an optimal plan with extra variables?
56. Describe the mathematical model of the production program optimization.
57. Describe the mathematical model of load equipment optimization.
58. Describe the mathematical model of material optimization.
59. Describe the mathematical model of mixture.
60. Features of mathematical model for equipment replacement.
61. Define the term "game".
62. Selection of strategy players.
63. What is a saddle point?
64. Describe the nature of a game.

65. Optimal criterion in multicriteria problems.

66. Techniques of multicriteria decision problems.

67. How to select the single figure bonuses in solving production problems?

68. How to provide interconnection rate bonuses?

69. How to use mathematical functions to ensure the linkage results and prizes?

70. What is the scale of bonuses?

71. How to build standards scale?

72. What is the premium using the scale bonuses?

8. Individual consulting work

Individual consulting work consists of the following forms: individual lessons, consultation, examination of individual tasks, test tasks of the current control.

Organization of individual and advisory work has the following forms:

evaluation of theoretical material by consulting individual students (FAQ) and groups (considering the typical situations), the test objectives of this control;

assessment of the practical assimilation of the material held in individual and group counselling;

integrated assessment of the material held in the form of personal consultation and practical personal training and experimental tasks.

9. Methods of improving the process of learning

To improve teaching and students' learning such educational techniques are provided: problem lectures, small groups work, the use of special computer programs.

Specific methods of improving educational process are listed below.

While learning the discipline "Operations Research students study various economic-mathematical methods of operations research before they become familiar with the economy, organization and scheduling in

manufacturing plants. Therefore, to enhance the learning process only a few questions are included in lectures (Table 6).

Problem lectures are aimed at developing logical thinking of students. Students attention is focused on the material that is not reflected in the textbooks. Lecture topics are limited to two or three key points. Students are offered questions for self-study. Questions encourage students to seek solutions of the problem situation, using the previously studied material both in this discipline and in related ones.

Table 6

Use of Learning Technologies to enhance the learning process

Methods of enhancing the learning process	Practical use of educational technologies
Problem lectures focused on critical thinking and creative approach to study models and methods of operations research	Problem Lecture (question): "Methods of economic and mathematical modelling. Mathematical model of operations research. Using the methods of operations research in modern conditions "(Theme 1). Problem lecture with a question: "Mathematical Functions stimulation" (Theme 8)
Working in small groups provides structured practical training using computer programs, creating opportunities for the participation of each student	Working in small groups during all workshops will help accelerate the learning process, expand the range of issues to improve the reliability of the results of final decision

At the beginning, the problem to be solved is explained to students. While giving a lecture, a lecturer should avoid, direct answers to questions to give students the opportunity to solve the problem independently. At the end of a lecture the discussion with students should be organized to give them an opportunity to express their visions of solving this problem.

10. System of current and final control of students' knowledge

According to the syllabus of the discipline "Operations Research" the system of evaluation of students' knowledge and skills must be considered. This syllabus includes lectures, laboratory studies, independent work and individual performance objectives.

Control measures include the current and final module control.

Testing and evaluation of students' knowledge is conducted in the following forms:

1. Assessment of students' knowledge during lectures and practical classes.

2. Assessment of individual tasks.

3. Exercising current module control.

4. Conducting the final module control.

Assessment of practical knowledge and lecture components of modular control is carried out by 12-point scale according to the following criteria:

1) the degree of theory and methodology issues understanding;

2) the degree of understanding of factual material;

3) review of recommended literature, as well as modern references of the issues under consideration;

4) ability to combine theory and laboratory studies when considering the production situations, solving problems, carrying out calculations when performing tasks for self-study;

5) logic, structure, style of presentation in written work and in oral answers, the ability to justify their position, to summarize and draw conclusions.

Intermediate evaluation consists of two parts: a practical one and a lecture.

Assessment of practical component of the modular control is made by the results of students' assessment during their laboratory studies, as well as the individual tasks.

Assessment of students' knowledge during the laboratory studies is aimed to: review the level of preparedness of students to solve specific production situations and the individual teaching and research tasks;

to take into account active, systematic and effective work of a student during the semester to study the discipline;

attendance;

independence and timely delivery of assignments to the lecturer by the schedule of the educational process.

Systematic control of independent work is also conducted at laboratory studies and lectures.

Lecture test control should be exercised in writing.

Intermediate control test is conducted twice per semester and provides material for the students to identify and apply their skills to solve practical situation.

When conducting this test the students' knowledge of theoretical issues of the discipline are determined.

Test tasks have different levels of difficulty and cover key themes that are studied within the discipline "Operations Research".

Thus a test can contain a question concerning the theoretical material and questions directed at solving practical situation.

Format of tests is divided into tasks of closed and open forms. In tests of the open form a student has to give a free response.

Test tasks differ according to the principle of composing response.

Alternative test tasks suggest that there are two answers of "yes – no", "right – wrong" and so on. They are to verify the correctness of the choice or decision in folded form.

Test tasks to compare and contrast (for analysis relationship) are recommended to check the skills to detect features of different phenomena, situations, etc.

Test tasks with multiple answers "right – wrong" imply that the answers or solutions can only be correct or incorrect. They test the depth of knowledge and understanding of various aspects of phenomena and processes.

Test tasks depend on the definition used in the causal importance of checking understanding of a causal relationship between the two phenomena. A student must first determine true or false from each of the two statements separately.

Test tasks to reproduce the correct sequence, which require restructuring of data elements or any combination, used in case of testing skills and knowledge of the correct sequence of actions (regulatory activity) of algorithms, technological approaches, etc., and knowledge of generally accepted definitions, rules, laws, regulations fragments.

Test tasks include free open proposed tasks without answers, and are used to identify knowledge of terms, definitions, concepts.

Test tasks for the intermediate test control are chosen according to the relevant modules from the general list.

Example of modular test tasks:

1) give a sequence of economic problems decision stages of operations research;

2) give the construction stages of mathematical models queuing;

3) characteristics of the normal distribution law;

4) indicators (mullion or interval) used to construct the polygon distribution;

5) how to calculate dispersion index maintenance.

Intermediate test control is performed in reference work, which consists of 5 questions. Evaluation criteria are:

5 questions – 3 points;

4 questions – 3 points;

3 questions – 2 points;

2 questions – 2 points;

1 questions – 2 points.

3 points – answers of questions are complete, indicate a deep knowledge of the theoretical material; and a student uses both main and additional recommended literature, a student makes his/her own conclusions on this issue.

2 points – student does not fully reveal the basic knowledge of educational material.

1 points – student uses the course material without understanding, makes vague conclusions on this issue.

0 points – failed attempt to answer the question at all.

Responses of students are assessed by 12-point scale according to the qualification requirements for the Bachelor Degree specialization area "Management." Each task of the control model is estimated separately.

12 points are given for deep knowledge of material, the use of recommended and creative approach, clear mastering of the concepts, methods, techniques and tools of operations research, the ability to use them for specific practical problems and situations.

11 points are given for deep knowledge of material, clear own concepts, methods, techniques and tools of operation research, the ability to use them

for specific practical problems, solving situations. Answers questions should be logical and consistent.

10 points are given for full assimilation of program material and recommended literature, a clear conceptual possession of methods, techniques and tools of operation research, the ability to use them for specific practical situations. There may be occasional minor mistakes that significantly affect the completeness and consistency of a response.

9 points are given for full assimilation of the program and the existing ability to navigate in it, conscious knowledge to solve practical problems, in the presence of minor arithmetic errors (methodical approach to solving the problem is correct, but admitted to minor inaccuracies in calculation of certain parameters), or not quite full conclusions on the results obtained in the process of problem solving. Execution of a task should be accurate.

8 points are given for full application of existing skills to navigate in it, conscious application of knowledge to solve practical problems. Practical tasks are performed correctly in general using the default algorithm, but their performance by the student has certain errors.

7 points are given, if a student while carrying out practical tasks effectively uses the basic knowledge of educational material provided by the curriculum. Practical tasks are performed on the whole correctly using the default algorithm, but when accomplishing them a student makes substantial errors.

6 points are given for a lack of ability to apply theoretical knowledge to solve practical problems, if the tasks were performed and the main purpose of the task was accomplished, the students in responses demonstrated an understanding of the main issues of the subject learning.

5 points are given for a partial ability to apply theoretical knowledge to solve practical problems, if the task was partially completed, and students in responses showed understanding of the main points of the discipline.

4 points are given in cases when a student in carrying out practical tasks without sufficient understanding of the educational material, made substantial errors, facing difficulties in applying discipline material.

3 points are given to a student who cannot properly perform practical tasks facing considerable difficulties in learning the basic material provisions of the discipline.

2 points are given to a student, who did not master the program material, cannot properly perform practical tasks facing considerable difficulties in learning the basic material provisions of the discipline.

1 points are given for a failure to fulfil the task in general.

The condition for admission is a positive assessment of the current model knowledge control (for external students-defence of written tests).

An examination card includes three tasks.

Sample of a modular final task

1. The use of queuing theory.
2. Optimizing grid model.
3. Methods for solving multicriteria problems.

Final evaluation of the discipline is the arithmetic average of several components, which includes estimates of each control.

Final assessment of the discipline in accordance with the methods of transferring indicators of students success into University assessment scale ECTS is converted into the grade on the ECTS scale (Table 7).

Table 7

Transference of University Characteristics of Students' progress into the system of the ECTS scale

Percentage of students who usually successfully reach the appropriate assessment	ECTS assessing scale		Score point scale used in KhNUE	National scale assessment
1	2		3	4
10	excellent performance	A	12 – 11	excellent
25	above average	B	10	
30	work is correct in general, but with a number of errors	C	9 – 7	good
25	not bad, but many drawbacks	D	6	satisfactory

The End of Table 7

1	2		3	4
10	performance does not meet the minimum criteria	E	5 – 4	
-	needs re-taking	FX	3	unsatisfactory
-	repeated study of the discipline	F	2 – 1	

11. Recommended references

11.1. Main

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