МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ СЕМЕНА КУЗНЕЦЯ

ЗАТВЕРДЖЕНО
на засіданні кафедри
вищої математики та економіко-
математичних методів
Протокол № 1 від 21.08.2023 р.

ПОГОДЖЕНО
Проректор з навчально-методичної роботи

Каріна ПЕМАШКАЛО

ЕКОНОМІКО-МАТЕМАТИЧНІ МЕТОДИ В МІЖНАРОДНОМУ БІЗНЕСІ
робоча програма навчальної дисципліни (РПНД)

Галузь знань	**29 «Міжнародні відносини»**
Спеціальність	**292 «Міжнародні економічні відносини»**
Освітній рівень	**перший (бакалаврський)**
Освітня програма	**«Міжнародний бізнес»**

Статус дисципліни **вибіркова**
Мова викладання, навчання та оцінювання **англійська**

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Харків
2023

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

APPROVED
At the meeting of the Department of Higher Mathematics Economic and Mathematical Methods
Protocol № 1 dated 21.08.2023

AGREED
Vice-rector for educational and methodical work

_____ Karina NEMASHKALO

ECONOMIC AND MATHEMATICAL MODELS IN INTERNATIONAL BUSINESS

Program of the course

Field of knowledge	**29 International Relations"**
Specialty	**292 International Economic Relations**
Study cycle	**first (bachelor)**
Study programme	**International Business"**

Course status	**selective**
Language	**English**

Developers:

Doctor of Science, Professor _____ Lyudmyla MALYRETS

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Head of Study Programme _____ Natalia PARKHOMENKO

Kharkiv
2023

INTRODUCTION

A modern specialist in international economic relations must be well versed in mathematical tools and their implementation in various software environments in order to objectively assess the economic state of the countries of the world and their relations. It is the economic and mathematical methods that are the tool for researching various socio-economic systems, which allows obtaining reliable information about their characteristics. Thanks to mathematical methods, economic-mathematical models are developed and new knowledge and production of new knowledge is carried out. The implementation of all management functions in the international business takes place with the support of mathematical methods that provide opportunities to optimize the processes that take place in this field of activity, describe and forecast its states.

The main purpose of the educational discipline is to form the acquirers of competences in the theory and practice of applying mathematical optimization methods and methods and also models of econometrics for solving typical problems in the field of international economic relations, as well as the implementation of these methods on a computer.

The main tasks of the academic discipline are:

– study of basic economic and mathematical methods and their use in international business;

– analysis of international markets based on constructed models;

– formation of abilities and skills of research of economic processes and phenomena in the use of paired and multivariate regression models in international business.

The object of study of the discipline is the process of management in international business and the solution of various problems that arise during decision-making.

The subject of study of the academic discipline is the principles, forms and methods of solving optimization and econometric problems in international business.

The learning outcomes and competencies formed by the course are defined in table 1.

Table 1

Learning outcomes and competencies formed by the course

Learning outcomes	Competencies
LO4	SC2
LO7	SC3
LO10	SC5
LO12	SC6
LO18	SC11
LO24	SC15
LO27	SC18
LO29	SC20

where:

SC2. The ability to apply basic categories and the latest theories, concepts, technologies and methods to research in the field of international economic relations, taking into account their main forms, to apply theoretical knowledge about the functioning and development of international economic relations.
SC3. The ability to identify the peculiarities of the functioning of the environment of international economic relations and models of economic development.
SC5. The ability to carry out a comprehensive analysis and monitoring of global market conditions, to assess changes in the international environment and to be able to adapt to them.
SC6. The ability to analyze international markets of goods and services, instruments and principles of regulation of international trade.
SC11. The ability to conduct research on economic phenomena and processes in the international sphere, taking into account cause-and-effect and spatio-temporal relationships.
SC15. The ability to apply the methods, rules and principles of functioning of international economic relations for the development of Ukraine's foreign economic activity.
SC18. The ability to solve applied tasks in the areas of planning, analysis, organization and control of international business.
SC20. The ability to make and justify management decisions regarding the creation and operation of business structures, promoting the internationalization of business in the sector of small and medium-sized enterprises.
LO4. Systematize and organize information about processes and phenomena in the world economy; evaluate and explain the influence of endogenous and exogenous factors on them; formulate conclusions and develop recommendations taking into account the peculiarities of the national and international environment.
LO7. Apply the acquired theoretical knowledge to solve practical problems and meaningfully interpret the obtained results.
LO10. To identify and single out the peculiarities of the functioning of subjects of international relations and models of their economic development.
LO12. Carry out a comprehensive analysis of complex economic systems, evaluate their components and substantiate the evaluation results.
LO18. To study economic phenomena and processes in the international sphere, highlighting and generalizing the patterns of functioning and development trends of the world economy, taking into account cause-and-effect and spatio-temporal relationships.
LO24. Justify the choice and apply information and analytical tools, economic and statistical methods of calculation, complex analysis techniques and methods of monitoring the state of world markets.
LO27. Apply the acquired knowledge to solve applied problems in the areas of planning, analysis, organization and control of international business.
LO29. Make and substantiate management decisions regarding the creation of entrepreneurial structures and their activities, promotion of business internationalization in the sector of small and medium-sized enterprises.

COURSE CONTENT

Content module 1. Optimization methods in international business

Theme 1. Mathematical methods and models in international business. Linear programming problem

1.1. Meaning and principles of modeling

The subject and tasks of the discipline "Economic-mathematical models in international business". The place of modeling among methods of learning international business. Principles of modeling. Definition of the model. Mathematical model. Properties of international market models.

1.2. The main types of models

Classification of models. Economic and mathematical models and their classification. Definition of optimization and econometric models.

1.3. Stages of economic and mathematical modeling

The logic of the stages of economic and mathematical modeling, the content of each stage. Economic and mathematical modeling as a process of transformation of various models.

1.4. General formulation of the linear programming problem

Economic and mathematical statements of typical linear programming problems (LPP). Basic definitions.

1.5. The canonical form of the linear programming problem

Forms of linear programming problems. Presentation of LPP in the standard form. Canonical form of LPP. Transition from the standard form to the canonical form

Topic 2. Graphical and simplex methods of solving LPP

2.1. Geometric interpretation of LPP

Formulation of the problem. Level line. Polygon of plans. Support plans.

2.2. Algorithm of the graphic method of solving the LPP

The logic of the stages of implementation of the graphic method of solving LPP, its possibilities and scope of application.

2.3. Examples of problems that can be solved graphically

The problem of optimal use of raw materials. Diet problem. Transition from the canonical form of LPP to its standard form.

2.4. Algorithm of the simplex method of solving LPP

Construction of initial reference plans. Estimates of the plan. Criterion of optimality. The principle by which the improvement of the plan is carried out.

2.5. The problem of degeneration in the tasks of international business

Degenerate support plan. The problem of looping in the process of simplex transformations and ways to overcome it.

Topic 3. Theory of duality

3.1. Rules for constructing mathematical models of mutually dual problems

Definition of conjugate problem. General principles of building a mathematical model of a dual model depending on the form in which the original model is presented.

3.2. Duality theorems
Basic duality theorems and their economic interpretation for international markets.
3.3. Economic interpretation of dual unknowns in international business
Economic interpretation of the direct and dual LPP on the example of the problem of optimal use of raw materials. Determination of the optimal plan of the original problem by the solution of the dual.

Topic 4. Elements of game theory. Analysis of risks in international business
4.1. Basic concepts of game theory
The basic concepts of game theory, the mathematical model of a matrix game as a special case of probabilistic models of economic systems. Two-person matrix games. Payment matrix.
4.2. Solving a matrix game in pure strategies
The pure strategy games, their economical interpretation. Saddle point.
4.3. Solving the matrix game in mixed strategies
The main theorem of game theory (Neumann's theorem). A graphical method for solving a two-person matrix game (with dimensions of 2x*n* or *m*x2). Determination of active strategies of players. Analytical method of solving the two-person matrix game and its use in international business.

Content module 2. Econometric methods in international business

Topic 5. Peculiarities of econometric models in international business and principles of their construction
5.1. Features of econometric models. The value and place of econometric models in the analysis of international markets
Subject, object, methods and tasks of econometrics. Connection of econometrics with other disciplines. The role and place of econometric models in the analysis of socio-economic systems.
5.2. Formation of a set of observations
Statistical base for building econometric models. The concept of homogeneity of observations. Accuracy of output data.
5.3. The main stages of building econometric models in international business
Definition of the model. Types of connection between the factors characterizing the modeling object. Econometric model, its structure. The main stages of econometric analysis of economic phenomena and processes.

Topic 6. Paired regression and correlation in international markets and testing the quality of the paired regression equation
6.1. Linear regression and correlation: content and estimation of parameters
General information about statistical evaluations. Estimating the parameters of a linear pairwise regression model using the method of ordinary least squares (OLS).
6.2. Examples of solving economic problems in international business
Prerequisites of regression analysis. Point forecast based on the econometric model. Examples of implementation in international business.

6.3. Nonlinear regression for the analysis of international markets

Peculiarities of justification of the form of the econometric model. Types of nonlinear models. Linearization methods. Examples of the application of non-linear models in economic research.

6.4. Analysis of variance. Coefficient of determination. Checking the quality of the constructed paired linear model

The problem of closeness and significance of the correlation relationship (variance analysis). Evaluation of the significance of model parameters. Checking the adequacy of the model. Estimation of statistical significance of regression and correlation coefficients.

6.5. Calculation of forecast intervals according to the equation of linear paired regression

Reliability of forecast. Confidence interval for the estimated value.

Topic 7. Linear models of multiple regression and reliability assessment of its results

7.1. General issues of building a multiple regression model

Model specification. Estimating the parameters of the regression equation. Methods of constructing multivariate linear regression. The method of least squares (LSM), statistical properties of LMS estimates.

7.2. The matrix form of the linear multiple regression model

Peculiarities of providing raw data in matrix form. Coefficient of multiple determination.

7.3. Multiple linear regression model in standardized variables

Standardized variables. β - coefficients and their interpretation. Pairwise, partial and multiple correlation coefficients. Multiple and partial correlations in international business problems.

7.4. Checking the overall quality of the regression equation

Standard error of the equation; coefficient of determination; multiple correlation coefficient. Checking the model for adequacy. Fisher-Snedecor test.

7.5. Checking the statistical significance of the model parameters

Checking the significance of parameters of the regression equation. Student's criterion. Serial connection method (exclusion).

Topic 8. Modeling of one-dimensional time series

8.1. The main elements of the time series

Matrix method of constructing time series. Use of dummy variables to determine seasonal fluctuations. Point and interval forecasts by time series.

8.2. Autocorrelation of time series levels and detection of its structure

Lag. Determination of the autocorrelation coefficients of the first order, second order, third order, etc. Correlogram.

Topic 9. Time series trend modeling. Forecasting in international business

9.1. The application of growth curve models for forecasting the main trends in the development of international markets

The moving average method. Decomposition method for determining the trend line equation. Forecasting general development trends.

9.2. Methods of choosing growth curves and assessing the adequacy and accuracy of selected models in international business

Extrapolation of trends from one-dimensional time series. Assessing the adequacy of the forecast depending on the type of function that describes the trend of changes in the characteristics of international markets.

Topic 10. Integral indicators on international markets

10.1. Integral indicator as a comprehensive characteristic of processes and phenomena

Definition of an integral indicator. Algorithm for constructing integral indicators. Principles of transformation of the components included in the integral indicator. Additive and multiplicative convolution methods.

10.2. Application of integral indicators to characterize processes in international markets

Peculiarities of interpretation of the results of calculation of integral indicators obtained using a unified scale.

The list of practical (seminar) / laboratory studies in the course is given in table 2.

Table 2

The list of practical (seminar)) / laboratory studies

Name of the topic and/or task		Content
Topic 1	Practical class 1	Studying the content and types of models used to solve practical problems in international business. Compilation of mathematical models of Linear Programming Problems
Topic 2	Laboratory class 1	Familiarization with the MS Excel software environment. Study of built-in functions and add-ons of MS Excel used in economic and mathematical modeling
	Practical class 2	Application of the graphic method to the solution of LPP
	Laboratory class 2	Application of built-in functions and add-ons of MS Excel to solve the problem of optimal allocation of resources
	Practical class 3	Application of the simplex method to solving optimization problems of linear programming in international business
Topic 3	Laboratory class 3	Studying the peculiarities of building a mathematical model of a dual problem using the example of the problem of optimal use of resources, calculating estimates of the optimal plan and studying its stability
	Practical class 4	Construction of mathematical models of a conjugate pair of dual problems. Determination of the solution of the original problem by the solution of the dual problem and their interpretation in international business.
Topic 4	Laboratory class 4	Studying the peculiarities of building a mathematical model of a two-person matrix game, which involves determining the optimal strategy under conditions of risk
	Practical class 5	Solving a matrix game in pure strategies. Solving 2xn or mx2 matrix games using graphical and analytical methods
Topic 5	Laboratory class 5	According to the observation data (X, Y) is required: a) estimate

		the parameters of the linear model $\hat{y} = b_0 + b_1 \ x$; b) construct a theoretical regression line and a confidence interval to which it belongs with 95% reliability; c) give an interpretation of the results for international business problems
Topic 6	Practical class 6	The development of paired linear regression models of the dependence of the result characteristic on the factor characteristic. Model specification definition, model parameters estimation, point and interval estimations of equation parameters, forecast calculation
	Laboratory class 6	Checking the quality of the paired linear regression model by Student's and Fisher's tests
Topic 7	Practical class 7	Construction of linear multiple regression models using the least squares method. Interpretation of the parameters of the equation. Assessment of model quality. Checking the expediency of the presence of each of the exogenous factors in the model
	Laboratory class 7	Based on the observations a) calculate the parameters of the linear model in matrix form for the case of two exogenous variables; b) make calculations of the same parameters using the function LINEST
Topic 8	Practical class 8	Study of the structure of time series. Checking for autocorrelation. Construction of a time series model using dummy variables. Comparison of forecasts by different time series models for the analysis of international markets
	Laboratory class 8	Familiarize yourself with the effect of autocorrelation and standard methods of neutralizing the harmful consequences of violating the Gauss-Markov hypothesis about the uncorrelation of model residuals
Topic 9	Practical class 9	Calculation of models of growth curves for forecasting the main trends in the development of international business. Selection of growth curves and assessment of adequacy and accuracy of selected models
Topic 10	Laboratory class 9	The use of integral indicators for the analysis of international markets

The list of self-studies in the course is given in table 3.

Table 3

List of self-studies

Name of the topic /or task	Content
Topics 1 - 10	Studying lecture material
Topics 1 - 9	Preparation for practical classes; doing homework
Topics 2 - 10	Completion of tasks for independent solution according to laboratory works
Topics 1 - 10	Preparation for colloquiums and tests
Topics 1 - 10	Writing an independent creative work
Topics 1 - 10	Preparation for exams

The number of hours of lectures, practical (seminar) studies and hours of self-study is given in the technological card of the course.

TEACHING METHODS

The methods used during the teaching of the academic discipline "Economic and Mathematical Models in International Business" are aimed at the formation of defined competencies. Verbal (lectures), visual (demonstration), practical (exercises, experiments) methods, i.e., methods based on the source of knowledge (transmission and perception of educational information), are used throughout the entire time of teaching the discipline.

In order to enhance the educational and cognitive activities of students such interactive forms of teaching provide for the use. There are presentations, computer simulations, visual support banks, "Flipped classroom". During lectures, practical and laboratory classes, the use of explanatory and illustrative methods (Topics 1-10), reproductive methods using elements of problem presentation (Topics 4, 8-10), as well as research and heuristic methods (Topics 1-10) is expected. In order to activate and stimulate the educational and cognitive activity of students, presentations are used during lectures (Topics 1-10), as well as individual research work, the result of which is the preparation of independent creative work. The application of these technologies is aimed at the formation of competencies that are defined for each theme of the discipline.

FORMS AND METHODS OF ASSESSMENT

The university uses a 100-point accumulative system for evaluating the learning outcomes of students of higher education.

Current control is carried out during lectures, practical, laboratory and seminar classes and is aimed at checking the level of readiness of the student to perform a specific job and is evaluated by the number of points scored:

− for courses with a form of semester control as an exam: maximum amount is 60 points; minimum amount required is 35 points.

The final control includes current control and an exam.

Semester control is carried out in the form of a semester exam or grading.

The final grade in the course is determined:

− for disciplines with a form of exam, the final grade is the amount of all points received during the current control and the exam grade.

During the teaching of the course, the following control measures are used:

Current control: colloquiums (estimated at 7 points (two colloquiums during the semester – the total maximum number of points – 14)); written tests (maximum score – 8 points (two written tests during the semester, total maximum number of points – 16)); homework (maximum score – 2 points (six homework during the semester, total maximum number of points – 12 points)); laboratory work (maximum score – 2 points (six laboratory work during the semester, total maximum number of points – 12 points)); an independent creative task (maximum score – 6 points).

Semester control: Grading including Exam (40 points).

More detailed information on the assessment system is provided in technological card of the course.

An example of an exam card and assessment criteria.

An example of examination paper

Form № H-5.05

SEMEN KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

Educational level: first (bachelor)

Term 3

Educational discipline: Economic and Mathematical Models in International Business

Examination paper (EXAMPLE)

Task 1 (6 points)

The person making the decision analyzes the implementation of two business projects of the international company. The company's profit for each project, depending on the competitor's strategy, is represented by the matrix:

$$P = \begin{matrix} 8 & 2 & 8 & 9 & 1 \\ 10 & 7 & 3 & 1 & 5 \end{matrix}.$$

Solve the given matrix game graphically and analytically. Explain the results obtained.

Task 2 (8 points)

For the production of two types of products A and B, the enterprise uses three types of raw materials. Draw up a production plan, in which the company's profit from the sale of products will be maximum, provided that products B must be created no less than products A. The conditions of the task are given in the table:

Output data

A type of raw material	**The rate of consumption of raw materials per unit of production, kg**		**Raw material reserves, kg**
	A	*B*	
I	2	3	24
II	12	15	60
III	4	4	12
IV	8	12	40
Profit from the sale of one product, money unit	30	40	

Solve the problem graphically.

Task 3 (8 points)

Solve Task 2 using the simplex method and provide an economic interpretation of the obtained results.

Task 4 (8 points)

The table shows the weekly profit (X) and weekly consumption (Y) for an enterprise engaged in international business:

X	100	120	140	160	180	200	220	240	260	280
Y	60	70	90	100	110	120	120	150	140	180

Construct a linear regression and interpret the regression coefficient. Check the significance of the constructed model.

Task 5 (10 points)
For 50 factories, the dependence of labor productivity (y) on the level of worker qualification (x_1) and the level of labor automation (x_2) is studied. The data are given in the table:

Factor	Average value	Mean square deviation	Pairwise correlation coefficient
y	100	8,2	$r_{yx_1} = 0{,}65$
x_1	5,7	2,3	$r_{yx_2} = -0.54$
x_2	4,3	0,9	$r_{x_1x_2} = 0{,}85$

Construct multiple regression equations in standardized variables, provide an economic interpretation of regression coefficients. Find the multiple coefficient of determination. Check the significance of the model as a whole and the expediency of the presence of each of the exogenous factors in the model.

It was approved at the meeting of the department of higher mathematics and economic mathematical methods

Protocol № _ from ___, 20__

The head of the department L. Malyarets

The lecturer S. Lebedev

An assessment criterion

Each examination paper contains 5 practical tasks, including one first-level (diagnostic) task, three second-level (situational) tasks and one third-level (heuristic) task.

***Task 1 of the first level* (*diagnostic*) *is evaluated*:**
6 points, if the problem on the topic of matrix game theory is correctly solved; all the key points of the solution are substantiated. The economic-mathematical model is clearly described, its solution is commented, the analysis of the obtained results is carried out;
5 points, if the problems are correctly solved, but no interpretation of the obtained results is given;

4 points, one minor error or typo in the calculations is possible, which does not affect the correctness of the subsequent solution;
3 points, in the correct sequence of solving stages, its individual stages are missing. The key points of the solution are not substantiated. The answer obtained is close to the correct one. The problems are not completely solved;
2 points, problem solving has started, there are some correct considerations, but a logical error was made at the beginning of the problem, which led to an incorrect solution;
1 point, if the problem solving is started, but almost all the reasoning is not accurate, and therefore the problem solving is not correct.

Tasks 2 and 3 of the second level* (*stereotype*) *are evaluated*:***
8 points each task, if the problems are solved flawlessly, all the key points of the solution are substantiated. Solving by graphical and simplex methods is accompanied by explanation and interpretation;
7 points, if the problems are solved correctly, but the key points of the solution are not justified. Solving by graphical and simplex methods is not accompanied by an explanation and interpretation from the point of view of economics;
6 points, the problems are solved correctly, but there are no explanations of the intermediate results of the solution. A typo in calculations is possible, which does not affect the correctness of the subsequent solution;
5 points, if the problems are not solved to the end, because one minor calculation error was made, which does not affect the correctness of the further solution, but the solution was not continued;
4 points, in the started correct sequence of stages of the solution, some of its stages are missing, and the mistake made led to an incorrect answer. The partial solution presented in the paper is commented, but the problems are not completely solved;
3 points, in the correct solution started, an error was immediately made, which led to an incorrect answer;
2 points, the course of solving problems is not correct, but individual stages indicate knowledge of some standard techniques for solving linear programming problems, the use of graphic and simplex methods;
1 point, problem solving has started, there are some correct considerations, but a fundamental error has been made from the beginning of the problem.

Task 4 of the second level* (*stereotype*) *is evaluated*:***
8 points, if the general knowledge of the theoretical foundations of econometrics is demonstrated, the necessary formulas are given, the correct calculations are made, a graph is drawn according to the regression equation;
7 points, if the knowledge of the theoretical material and the ability to correctly perform calculations is demonstrated, the results obtained were analyzed, but some key points of the solution were not sufficiently substantiated;
6 points, if the correct solution algorithm is given, the calculations do not contain errors, separate theoretical explanations of the obtained results are provided, but they are only of a general nature;

5 points, if the correct solution algorithm is given, the necessary explanations are given regarding the application of the formulas, however, one minor error was made during the calculations, which did not affect the theoretical conclusions resulting from these calculations;
4 points, if the necessary formulas are given, a theoretical justification for their application is partially provided, but one or two gross errors were made during the calculations, which affected the result and led to false conclusions;
3 points, if the necessary formulas are given without explanations regarding their application, and one or two gross errors were made during the calculations, which significantly affected the result and led to false conclusions, or the necessary theoretical conclusions are absent at all;
2 points, if the task as a whole is not completed, but there is an approach to its completion (several correct formulas are given or some elementary calculations of fragments of the task are carried out);
1 point, if only the initial condition is recorded.

***The task of the third level* (*heuristic*) *is evaluated**:*
10 points, if the task solution is characterized by creative use of theoretical material, logic, clarity and reasonableness of conclusions, rationality. A perfectly executed task is accompanied by a demonstration of in-depth knowledge of the discipline, which corresponds to the acquired competences in modeling the multivariate regression equation;
9 points, if the logically correct sequence of solution steps is given, its individual key points are substantiated. The justification of the used formulas is provided. One minor error or typo in the calculations is possible, which does not affect the correctness of the subsequent solution and interpretation of the results;
8 points, if a logically correct sequence of solution steps is given, its key points are substantiated. However, there are 1-2 minor errors or typos in calculations that do not affect the correctness of the subsequent solution;
7 points, if the mathematical terminology is correctly used and the main steps of the solution algorithm are constructed, the necessary formulas are given. Only certain key points of the solution are substantiated, but not all the necessary explanations are given;
6 points, if the task is basically completed, but without justification and with errors in calculations. There is no interpretation of the results;
5 points, if the task is only partially solved, the mathematical toolkit was used with errors that affected the final result;
4 points, if the task is only partially solved with the initial correct reasoning about the research algorithm, but there are errors that significantly affected the process of correct solution and led to a wrong interpretation of the results;
3 points, if the task was started, theoretical material was used at the level of basic definitions, some correct formulas for calculations were chosen and written down, but the result of their application was not given or logical errors were made that led to a fundamentally incorrect solution;

2 points, if the task as a whole is not completed, but there is an approach to its solution: several correct formulas are given, or some elementary calculations of fragments of the task are carried out;
1 point, if only the initial condition is recorded.

RECOMMENDED LITERATURE

Main

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