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

ЗАТВЕРДЖЕНО
на засіданні кафедри
економіко-математичного
моделювання
Протокол №16 від 29.08.2025.р.

ПОГОДЖЕНО
Проректор з навчально-методичної роботи
_____ Каріна НЕМАШКАЛО

ВИЩА МАТЕМАТИКА У МІЖНАРОДНИХ ЕКОНОМІЧНИХ ВІДНОСИНАХ

робоча програма навчальної дисципліни (РПНД)

Галузь знань	С Соціальні науки, журналістика, інформація та міжнародні відносини
Спеціальність	С1 Економіка та міжнародні економічні відносини
Освітній рівень	перший (бакалаврський)
Освітня програма	Міжнародні економічні відносини

Статус дисципліни	обов'язкова
Мова викладання, навчання та оцінювання	англійська

Розробники:
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Завідувачка кафедри
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Гарант програми _____ Наталія ПАРХОМЕНКО

Харків
2025

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

APPROVED

at the meeting of the Department of Economic and Mathematical Modeling

Protocol No16 from 29.08.2025

AGREED

Vice-Rector for educational and methodological Work

_____ Karina NEMASHKALO

HIGHER MATHEMATICS
IN INTERNATIONAL ECONOMIC RELATIONS
Program of the Course

Field of knowledge	C Social Sciences, Journalism, Information and International Relations
Specialty	C1 Economics and International Economic Relations
Study cycle	first (bachelor)
Study programme	International Economic Relations

Course status	mandatory
Language	English

Developers:

PhD (physics and mathematics) associate professor _____ Irina LEBEDEVA

senior lecturer _____ Stepan LEBEDEV

Head of the Department of Economic and Mathematical Modeling _____ Lyudmyla MAIYRETS

Head of Study Programme _____ Natalia PARKHOMENKO

Kharkiv
2025

INTRODUCTION

The current stage of economic globalization and the formation of an information society necessitates the active use of mathematical tools in all areas of practical activity in general and in the service sector, in particular, in international relations. The application of mathematical methods to solving practical problems in economics and management allows: to improve the systematization of economic information through its ordering, to identify shortcomings in existing information and to develop requirements for the preparation of new information; to increase the accuracy and reliability of economic calculations; to conduct a comparative analysis, if the existence of several alternatives is assumed, and to determine the optimal solution; to deepen the quantitative analysis of economic problems.

In solving problems of managing economic processes, increasing the efficiency of international business management, the leading place is occupied by methods and means not only of mathematical analysis, but also of computational mathematics. Therefore, every future economist, company manager, business owner, civil servant needs a thorough mathematical preparation that forms analytical and research competencies, and also provides the opportunity to apply mathematical tools using computer technology to solve a wide range of problems in the field of their professional activity.

The purpose of the academic discipline is to form a holistic system of theoretical knowledge of the mathematical apparatus, which helps to research, analyze and solve economic problems; to assist in mastering mathematical methods that make it possible to study and predict the dynamics of economic and social processes and phenomena in the field of future professional activity; to improve logical and algorithmic thinking; to promote the formation of skills and abilities for independent research and analysis of economic problems, and to develop a desire to find scientific ways to improve one's professional activity.

The objectives of the academic discipline are:

– mastering the theoretical foundations of mathematical methods used in determining indicators that characterize economic processes and phenomena;

– formation of skills and abilities in the study of economic processes and phenomena using methods of quantitative assessment of the state of an economic object;

– acquiring practical skills in using computer programs for data analysis.

The subject of study is general methods of analyzing temporal and spatial data.

The subject of the academic discipline is the mathematical apparatus, with the help of which it is possible to evaluate quantitative indicators of objects of an economic nature, to study functional and correlation relationships between indicators that determine the state of an economic object or process in the system of international business.

The learning outcomes and competencies that the academic discipline forms are defined in Table 1.

Table 1

Learning outcomes and competencies

Learning outcomes	Competencies
LO3	SC11
LO4	SC 5
LO12	GC8
LO 13	GC 8
LO 18	SC11
LO 24	IC, GC 2, GC 8, SC11
LO 27	SC11

where IC. The ability to solve complex specialized tasks and practical problems in the field of international relations in general and international economic relations in particular, as well as in the process of learning, which involves the application of the latest theories and methods in conducting comprehensive studies of world economic relations, is characterized by the complexity and uncertainty of the conditions.

GC2. The ability to preserve and multiply moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and engineering, to use various types and forms of physical activity for active recreation and leading a healthy lifestyle.

GC8. Ability for abstract thinking, analysis and synthesis.

SC5. The ability to carry out comprehensive analysis and monitoring of the global market situation, assess changes in the international environment and be able to adapt to them.

SC11. Ability to conduct research on economic phenomena and processes in the international sphere, taking into account cause-and-effect and spatio-temporal relationships.

LO3. Use modern information and communication technologies, general and special-purpose software packages.

LO4. Systematize and organize the information received regarding 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.

LO12. Carry out a comprehensive analysis of complex economic systems, compare and contrast their components, evaluate and justify assessments of the effectiveness of their functioning.

LO13. Select and skillfully apply analytical tools for studying the state and prospects for the development of individual segments of international markets for goods and services using modern knowledge about methods, forms and instruments for regulating international trade.

LO18. To study economic phenomena and processes in the international sphere based on an understanding of categories and laws; identifying and generalizing trends, patterns of functioning and development of the world economy, taking into account cause-and-effect and spatial-temporal relationships.

LO24. Justify the choice and apply information and analytical tools, economic and statistical calculation methods, complex analysis techniques and methods of monitoring the situation in world markets.

LO27. Apply the acquired knowledge to solve applied problems in the areas of planning, analysis, organization and control of international business.

COURSE CONTENT

Content module 1. Linear algebra, analytical geometry

Topic 1. Elements of the theory of matrices and determinants

1.1. **Matrices**

Definition of a matrix, its types. Actions on matrices: addition, multiplication of a matrix by a number, by a matrix. Transpose of a matrix. Inverse matrix. Equivalent matrix transformations. Examples of using matrices in the study of economic processes.

1.2. **Determinants**

Definition of determinant. Properties of determinants. Some special determinants (of triangular, diagonal, identity matrices). Rules for calculating higher-order determinants by definition and expansion using Laplace's formulas.

Topic 2. General theory of systems of linear algebraic equations

2.1. Systems of linear algebraic equations

Definition of a system of linear algebraic equations, expanded and matrix forms of its writing. Definition of a solution to a system of linear algebraic equations. The concept of compatibility or incompatibility of a system of linear algebraic equations. Definite and indefinite systems of linear equations.

2.2. Methods for solving systems of linear algebraic equations

Solving systems of linear algebraic equations using Cramer's formulas. Kronecker-Capelli theorem. General, partial and support solutions of a system of n linear algebraic equations with m unknowns. Solving systems of linear algebraic equations using the Gauss method and the Jordan-Gauss method. Economic examples.

2.3. Homogeneous systems of linear equations

Definition of a homogeneous system of linear equations. Solution space of a homogeneous system, relationship of its dimension to the rank of the matrix. Fundamental system of solutions of a homogeneous system of linear equations. Examples of optimization problems.

Topic 3. Elements of vector algebra

3.1. Basic concepts of vector algebra

Types of vectors, comparison of vectors. Linear operations with vectors in geometric and coordinate forms, properties of these operations. Scalar product of vectors, its properties. Angle between vectors. Collinear vectors, condition of collinearity. Vector and mixed products of vectors, their geometric interpretation and their properties. Condition of coplanarity of vectors.

3.2. Elements of the theory of linear spaces

Definition of n-dimensional vector and n-dimensional vector (linear) space. Linear independence of vectors. Definition and basic theorems on linear dependence and linear independence of elements of linear space. Basis of linear space. Vector coordinates in a given basis. Transition to another basis. Economic examples.

Topic 4. Elements of analytical geometry

4.1. Analytical geometry on the plane

Line on the plane. Varieties of equations of a line on the plane and the transition from them to the equation of general form. Distance from a point to a line. Curves of the 2nd order. Circle, ellipse, hyperbola, parabola: their definition, canonical equation, parameters, eccentricity, graph. Reduction of the general equation of a curve of the 2nd order to the canonical form.

4.2. Analytical geometry in space

Varieties of equations of a plane in space and transition to a general equation. Analysis of the mutual location of two planes. Distance from a point to a plane. Varieties of equations of a line in space and transition to a general equation. Analysis of the mutual location of two lines and a line and a plane in space. The most important types of 2nd order curves. Study of the shape of 2nd order curves by the method of sections.

Content module 2. Elements of mathematical analysis

Topic 5. Limits of functions and continuity

5.1. Sets, functions, their classification

Numerical sets. The concept of a function of one variable. Methods of defining functions. Domains of definition and values of a function. Basic elementary functions, their properties and graphs. Complex functions, functions that are given implicitly and functions that are given parametrically. Special functions used in economics.

5.2. Function limits

Definition of the limit of a function at a point, its geometric meaning. Infinite limits and limits at infinity. One-sided limits of a function at a point. Equivalent infinitesimal functions. Application of limits to solving economic problems.

5.3. Continuity of functions

Definition of continuity of a function at a point. Continuity of elementary functions. Points of discontinuity of functions and their classification.

Topic 6. Differential calculus of functions of one variable

6.1. Derivative and differential. Differentiation technique

Definition of derivative, its economic and geometric meaning. The concept of differentiability of a function at a point. Basic rules of differentiation. Table of derivatives of elementary functions. Derivative of a composite function. The concept of the differential of a function, its geometric meaning. L'Hôpital's rule for calculating the limits of functions.

6.2. Applying derivatives to the study of functions

Signs of monotonicity of a function, finding local extrema of a function. The largest and smallest value of a function on an interval. Conditions for convexity and concavity of a function graph, finding inflection points. Vertical, horizontal and oblique asymptotes of a curve. Scheme of a complete study of a function of one variable and construction of its graph.

6.3. Application of the derivative in economics

Marginal analysis. Elasticity of economic indicators.

Topic 7. Analysis of functions of many variables

7.1. Definition of a function of many variables

Basic concepts. Definition of a function of many variables, methods of solving. Domain of a function of two variables and its graph. Lines and level surfaces. Continuity of a function of two variables.

7.2. Gradient and derivative with respect to direction

Partial derivatives of functions, their geometric and economic meaning. Directional derivative of a function of several variables. Gradient of a function and its properties. Relationship between gradient and level lines for a function of two variables.

7.3. Extremum of a function of two variables

Local extremum of a function of two variables, necessary and sufficient conditions for an extremum. The largest and smallest value of a function in a closed domain. Conditional extremum. Application of a function of two variables in economics: production functions, Cobb-Douglas function, cost function, demand function.

Topic 8. Indefinite integral

8.1. Initial and indefinite integral

Definition of the antiderivative function and indefinite integral. Properties of the indefinite integral. Table of basic indefinite integrals. The concept of integrals that are "not taken".

8.2. Basic integration methods

Direct integration method. Method of replacing a variable (substitution) in an indefinite integral. Formula for integration by parts, main cases of its use.

Topic 9. Definite integral and its applications

9.1. The concept and properties of a definite integral

Definition of a definite integral, its geometric meaning. Conditions for the integrability of a function. Properties of a definite integral and their application in calculation. Theorem on the mean.

9.2. Calculating a definite integral

Newton-Leibniz theorem. Substitution of a variable in a definite integral. Integration by parts formula for a definite integral.

9.3. Improper integrals of the first and second kind

The concept of improper integrals with infinite limits of integration and improper integrals of unbounded functions. Conditions for convergence of improper integrals.

Topic 10. Differential equations

10.1. Basic concepts of the theory of differential equations

Solving 1st order differential equations. 1st order differential equations: basic definitions, concepts of general and partial solutions. Problem. Differential equations with separable variables, homogeneous 1st order differential equations, linear 1st order differential equations.

10.2. Higher-order differential equations

Basic concepts and definitions, general and partial solutions, Cauchy problem. Differential equations of the 2nd order. Equations that allow reduction of order. Linear differential equations of the 2nd order, structure of the general solution. Homogeneous linear differential equations of the 2nd order with constant coefficients. Linear differential equations of the 2nd order with constant coefficients and a special right-hand side.

Topic 11. Rows

11.1. Number series and their convergence

Definition of a numerical series and its sum. Convergence of a numerical series. Properties of convergent series. Necessary condition for convergence. Harmonic series, its divergence. Sufficient signs of convergence of positive numerical series: comparison sign, d'Alembert sign, Cauchy radical sign and Cauchy-Maclaurin integral sign.

11.2. Alternating series and their convergence

Definition of alternating series. Alternating series. Sufficient sign of convergence. Absolute and conditional convergence. Leibniz sign. Application of Leibniz's theorem to determining the error of calculating the sum of a series.

11.3. Functional series

The concept of functional series. Radius and region of convergence of a power series, formulas for their calculation.

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	Contents
Topic 1. Practical study 1	Elements of the theory of matrices and determinants
Topic 2. Laboratory study 1	General theory of systems of linear algebraic equations
Topic 2. Practical study 2	Homogeneous systems of linear equations
Topic 3. Laboratory study 2	Elements of the theory of vector algebra
Topic 4. Practical study 3.	Elements of analytical geometry
Topic 5. Laboratory study 3	Limits of functions and continuity
Topic 6. Practical study 4	Study of a function of one variable
Topic 7. Laboratory study 4	Researching a function of several variables
Topic 8. Practical study 5	Finding indefinite integrals
Topic 9. Laboratory study 5	Calculating definite integrals
Topic 9. Practical study 6	Solving economic problems that reduce to calculating definite integrals
Topic 10. Laboratory study 6	Solving differential equations
Topic 11. Practical study 7	Study of number series

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

Table 3

List of self-studying

Name of the topic and/or task	Content
Topics 1 - 11	Studying lecture material
Topics 1 - 11	Preparation for practical and laboratory studies
Topics 1 - 11	Preparation for written tests and colloquiums
Topics 1 - 11	Preparation tasks for self-studying
Topics 5 or 7	Preparation a creative task
Topics 1 - 11	Preparation for the final exam

The number of hours of lectures, practical and laboratory classes and hours of independent work is given in the technological card of the course.

TEACHING METHODS

In the process of teaching the course in order to achieve certain learning outcomes and activate the educational process, the use of such teaching methods as:
Verbal (lecture (Topics 1-11), problem lecture (Topics 3, 10)).
Visual (demonstration (Topics 1-11)).
Practical (practical classes (Topics 1-11), laboratory work (Topics 1-11)).
Presentation and/or speeches to an audience (Topics 5, 7).
Didactic game (Topic 10).

FORMS AND METHODS OF ASSESSMENT

The university uses a 100-point cumulative system for assessing the learning outcomes of higher education applicants.
Current control is carried out during lectures, practical, laboratory and seminar classes and is aimed at checking the level of preparedness of a higher education applicant to perform specific work and is assessed by the sum of the points scored. For disciplines with a semester control form of an exam (exam): the maximum amount is 60 points; the minimum amount that allows a higher education applicant to take an exam (exam) is 35 points.
Final control includes semester control and certification of the higher education applicant.

Semester control is carried out in the form of a semester exam (exam). The semester exam (exam) is taken during the examination session.
The maximum number of points that a higher education applicant can receive during an exam is 40 points. The minimum amount at which the exam is considered passed is 25 points.
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: 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)), written tests (maximum score – 8 points (two written tests during the semester, total maximum number of points – 16)), colloquiums (estimated at 7 points (two colloquiums during the semester – the total maximum number of points – 14)), 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 the technological card of the course.

An example of an exam card and assessment criteria.

An example of examination card

SEMEN KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS
Study cycle: first (bachelor)
Term I
The course "Higher Mathematics in International Economic Relations"

EXAMINATION PAPER No

Task 1 is diagnostic. It consists of 4 tasks, worth 4 points each, therefore, 16 points.

1	Given a system of linear algebraic equations: $$\begin{cases} -x_1 + 3x_2 + 2x_3 = -2, \\ x_1 + 2x_2 + x_3 = 3, \\ -x_1 + 2x_2 + 4x_3 = 3. \end{cases}$$ How many general solutions does this system have? Choose the correct answer: - the system has a unique solution, since the number of equations is equal to the number of unknowns; - the system has 2 general solutions; - the system has 3 general solutions

2	Function specified: $$y=\begin{cases}2x+1, & if\ x<0;\\ x^2-1, & if\ x\geq 0.\end{cases}$$ Examine it for continuity. Choose the correct answer: - the function is continuous on its entire domain of existence; - at the point $x = 0$ the function has a discontinuity of the first kind (finite jump); - at the point $x = 0$ the function has a discontinuity that is eliminated; - the function is undefined at the point $x = 0$
3	What does a gradient indicate? Illustrate the definition with a picture. Choose the correct answer: - the direction of the gradient points to the maximum point; - the gradient is directed towards the minimum point; - gradient is the derivative of the direction that is tangent to the contour line; - the gradient indicates the direction of the fastest growth of the function at a given point
4	We have the Cauchy problem: $$y''-4y'+4y=0,\quad y(0)=2,\ y'(0)=3.$$ Determine how many arbitrary constants its solution has. Choose the correct answer: - the solution does not contain arbitrary constants; - the solution to the problem contains one arbitrary constant, since the roots of the characteristic equation are multiples; - the solution to the problem contains two arbitrary constants, since this is a 2nd order equation

Task 2 – stereotyped. Consists of 2 tasks of 7 points each, therefore, 14 points.

1	Using the Jordan-Gauss method, determine the general solution of the system of linear algebraic equations, assuming that the free unknown is x_4. $$\begin{cases}x_1+3x_2+x_3+x_4=10;\\ 2x_1+x_2-x_3+2x_4=11;\\ 3x_1-2x_2+x_3+2x_4=19.\end{cases}$$ Determine the partial solution provided that $x_4 = 5$. In the answer, indicate the sum of all components of this partial solution
2	When new equipment was put into operation, its performance during the first month of operation was described by the function: $$y(t)=6t^3+4t^2+3.$$ Determine how many units of a product were produced in the first month if the product was not previously produced

Task 3 – heuristic. Contains 1 task of 10 points

1	Given function: $$y=1-\frac{x^2+1}{x^2-1}.$$ Conduct a complete study of this function and plot its graph

The solution and answers to all tasks must be provided in the form of a file, which must be submitted to the appropriate box on the PLS.

Approved at the meeting of the Department of Economic and Mathematical Modeling

Protocol No ____ from "___"_____ 20___

Examiner
senior lecturer _____Stepan LEBEDEV

The head of the department
doctor of economics, professor _____ Lyudmyla MAIYRETS

Evaluation criteria

Level 1 (diagnostic) tasks assess:
4 points for each of the 4 tasks, if general knowledge of the theoretical foundations of higher mathematics is demonstrated;
3 points, if an error is made when rounding the calculation results;
2 points, if the result of the calculations is of the same order as the correct answer;
1 point, if the answer is written down, but it is incorrect;
0 points, if no task has been fulfilled.

Level 2 tasks (stereotypical) assess:
7 points for each of the 2 tasks, if the ability to correctly perform calculations based on the basic theorems of higher mathematics is demonstrated;
6 points, if an error is made when rounding the calculation results;
5 points, if the calculation result is correct, but slightly off-topic;
4 points, if the result of the calculations is of the same order as the correct answer;
3 points, if only half of the problem is solved correctly;
2 points, if only half of the problem is solved, but a rounding error is made;
1 point, if the answer is written down, but it is incorrect;
0 point, if no task has been fulfilled.

Level 3 (heuristic) tasks are evaluated:
10 points, if the solution to the task is characterized by creative use of theoretical material, logical correctness, clarity, validity of conclusions, rationality. A perfectly completed task in the work is accompanied by a demonstration of in-depth knowledge of the discipline, which corresponds to the acquired competencies in evaluating the properties of a function of one variable;
9 points, if a logically correct sequence of steps for solving the problem is given. Individual key points of the solution are justified. An analysis is performed to justify the formulas used. 1 minor error or typo in the calculations is possible, which does not affect the correctness of the subsequent solution and the interpretation of the results;
8 points, if the logically correct sequence of steps for solving the problem is given. Individual key points of the solution are justified. There are 1-2 minor errors or typos in the calculations that do not affect the correctness of the subsequent solution;
7 points, if mathematical terminology and the main steps of using the research algorithm are used correctly, the necessary formulas are given; individual key points of the solution are justified, but not all the necessary explanations are given;

6 points, if the task is mostly completed, but without justification and with calculation errors. No interpretation of the result;
5 points, if the problem is only partially solved, basic mathematical tools were used with errors that affected the process of correctly solving the problem;
4 points, if the task is only partially solved with initial correct reasoning about the research algorithm, but there are errors that significantly affected the process of correctly solving the task and led to an incorrect interpretation of the results;

3 points, if the task has been started, theoretical material at the level of basic definitions has been used, the correct formulas for calculations have been selected and written down, but the result of their application has not been given or a logical error has been 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 completion (several correct formulas are given or some elementary calculations of fragments of the task are performed);
1 point, if only the initial condition is recorded;
0 point, if no task has been fulfilled.

RECOMMENDED LITERATURE

Main

1. Вища математика : базовий підручник для вузів / під ред. В. С. Пономаренка. – Харків : Фоліо, 2014. – 669.
2. Вища математика : підручник / [В. С. Пономаренко, Л. М. Малярець, Т. В. Денисова [та ін.]] ; за заг. ред. В. С. Пономаренка ; Харківський національний економічний університет ім. С. Кузнеця. –Електрон. текстові дан. (30,4 МБ). – 2-ге вид., випр. та допов. — Харків : ХНЕУ ім. С. Кузнеця, 2025. – 986 с. – Режим доступу : https://repository.hneu.edu.ua/handle/123456789/37921
3. Вища математика в GNU Octave : навч. посіб. / Е. Ю. Железнякова, Л. О. Норік; Харківський національний економічний університет ім. С. Кузнеця. — Електрон. текстові дан. (4,51 МБ). – Харків : ХНЕУ ім. С. Кузнеця, 2024. – 275 с. [Електронний ресурс] – Режим доступу : http://repository.hneu.edu.ua/handle/123456789/32499
4. Індивідуальні завдання з навчальної дисципліни "Вища математика" для студентів галузі знань 0305 "Економіка та підприємництво" денної форми навчання / Е. Ю. Железнякова, А. В. Ігначкова, Л. Д. Широкорад. – Харків : Вид. ХНЕУ ім. С. Кузнеця, 2014. – 217 с.
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Additional

6. Барковський В. Вища математика для економістів / В. Барковський, Н. Барковська. – Київ : Центр навчальної літератури, 2019. – 448 с.
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Черняка. – Київ: Видавничо-поліграфічний центр "Київський університет", 2008. – 497 с.
8. Клепко В. Вища математика в прикладах і задачах / В. Клепко, В. Голець. – Київ : Центр навчальної літератури, 2019. – 584 с.
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