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DEVELOPING THE PROFESSIONAL COMPETENCIES OF FUTURE MANAGERS THROUGH THE APPLICATION-BASED PROBLEMS IN ADVANCED MATHEMATICS

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Zhelezniakova E. Yu. Developing the Professional Competencies of Future Managers Through the Application-Based Problems in Advanced Mathematics

The current paradigm of higher education in Ukraine, particularly in the context of training management professionals, is undergoing fundamental transformations. The shift away from a purely theoretical instruction toward a practice-oriented approach requires a rethinking of the role of foundational disciplines, among which advanced mathematics occupies a central place. A key element of this transformation is the introduction of applied problems, which serve as a bridge between abstract mathematical concepts and the real-world challenges of managerial activity. The "Advanced Mathematics" course serves as the foundation for shaping the student's academic profile. The aim of the course is not only to master the terminological apparatus but also to develop students' cognitive flexibility: the ability to construct complex logical structures, manipulate abstract categories, and gain a deep understanding of the integration of mathematical methods into the global technological context. Strengthening the mathematical foundation of students in economic disciplines is a primary objective, as mathematical tools form the basis of professional skills. Knowledge of mathematical modeling methods and numerical data analysis is a prerequisite for solving practical economic problems and making efficient managerial decisions. The relevance of this article stems from the contradiction between the traditional abstract nature of advanced mathematics courses and the real needs of business in a wartime economy. Strengthening the applied focus through case studies and integration into LMS platforms allows for adapting manager training to conditions of uncertainty, where mathematical tools become the foundation for forecasting and minimizing risks. The process of training future managers requires a special approach to teaching mathematics, as students in this field often tend to perceive information through a humanities or social-behavioral lens. In this context, applied problems play a critical role in overcoming the psychological barrier between theory and professional practice. The implementation of this system of problems not only ensures a learning effect (the ability to apply mathematics in economics) but also plays an important developmental and educational role, shaping independent specialists with well-developed analytical thinking.

Keywords: *college student; linear algebra; matrix; analytical geometry; differential and integral calculus; derivative; integral; case study.*
Fig.: *1.* ***Formulae:*** *12.* ***Bibl.:*** *10.*

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Железнякова Е. Ю. Формування професійних компетентностей майбутніх менеджерів засобами прикладних задач вищої математики

Сучасна парадигма вищої освіти в Україні, особливо в контексті підготовки управлінських кадрів, зазнає фундаментальних трансформацій. Перехід від суто теоретичного навчання до практико-орієнтованого підходу вимагає переосмислення ролі базових дисциплін, серед яких провідне місце займає вища математика. Ключовим елементом цієї трансформації є введення прикладних задач, які слугують мостом між абстрактними математичними концептами та реальними викликами управлінської діяльності. Курс «Вища математика» слугує основою формування академічного профілю студента. Мета курсу полягає не лише в оволодінні термінологічним апаратом, а й у розвитку пізнавальної гнучкості студентів: здатності будувати складні логічні структури, оперувати абстрактними категоріями та здобувати глибоке розуміння інтеграції математичних методів у глобальний технологічний контекст. Зміцнення математичної бази студентів у економічних дисциплінах є основною метою, оскільки математичні інструменти становлять основу професійних навичок. Знання методів математичного моделювання та аналізу числових даних є передумовою для розв'язання практичних економічних проблем та прийняття ефективних управлінських рішень. Актуальність цієї статті випливає з протиріччя між традиційною абстрактною природою курсів вищої математики та реальними потребами бізнесу в умовах економіки воєнного часу. Зміцнення прикладної спрямованості шляхом розгляду кейсів та інтеграції до LMS-платформ дозволяє адаптувати підготовку менеджерів до умов невизначеності, де математичні інструменти стають основою для прогнозування та мінімізації ризиків. Процес підготовки майбутніх менеджерів потребує особливого підходу до викладання математики, оскільки студенти цієї сфери часто схильні сприймати інформацію через гуманітарну або соціально-поведінкову призму. У цьому контексті прикладні задачі відіграють важливу роль у подоланні психологічного бар'єру між теорією та професійною практикою. Реалізація цієї системи задач не лише забезпечує навчальний ефект (здатність застосовувати математику в економіці), але й виконує важливу розвивальну та виховну функцію, формуючи самостійних спеціалістів із добре розвинутим аналітичним мисленням.

Ключові слова: *студент коледжу; лінійна алгебра; матриця; аналітична геометрія; диференціальне та інтегральне числення; похідна; інтеграл; кейс-стаді.*
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The strategic focus of higher education reform in Ukraine is the training of adaptable and competitive professionals capable of performing effectively in highly uncertain environments. The key competence of such a specialist lies not only in mastering professional tools but also in the developed ability to generate non-trivial managerial decisions and engage in continuous self-education.

The current paradigm of higher education in Ukraine, particularly in the context of training management professionals, is undergoing fundamental transformations. The shift away from a purely theoretical instruction toward a practice-oriented approach requires a rethinking of the role of foundational disciplines, among which advanced mathematics occupies a central place. Mathematical tools and information technology occupy a special place in the modern architecture of professional training. They function not as abstract disciplines, but as the fundamental basis for the mathematical modeling of business processes. Mastering the skills of systems analysis, the ability to formalize and generalize complex patterns, as well as the ability to make verified, mathematically sound decisions are integral attributes of the professional resilience of the modern manager.

The «Advanced Mathematics» course, which is traditionally integrated into the early stages of study, serves as the foundation for shaping the student's academic profile. The number of credit units specified by educational and professional programs is aimed at creating a solid foundation, which is a critical prerequisite for the successful application of professional knowledge in further studies. The central goal of the discipline lies not only in mastering the terminological apparatus but also in developing students' cognitive flexibility: the ability to construct complex logical structures, manipulate abstract categories, and gain a deep understanding of the integration of mathematical methods into a global technological context.

The relevance of this article stems from the contradiction between the traditional abstract nature of advanced mathematics courses and the real needs of business in a wartime economy. Strengthening the applied focus through case studies and integration into LMS platforms allows for adapting manager training to conditions of uncertainty, where mathematical tools become the foundation for forecasting and minimizing risks. The process of training future managers requires a special approach to teaching mathematics, as students in this field often tend to perceive information through a humanities or social-behavioral lens. In this context, applied problems play a critical role in overcoming the psychological barrier between theory and professional practice. An applied problem in mathematics is defined as a model of a real-world situation, the solution of which requires the application of mathematical tools, and the result has a direct interpretation in the context of the original problem. Integrating such problems into the curriculum allows for the implementation of a multi-objective teaching strategy.

Analysis of scientific research and publications. The theoretical foundation of this study is based on a thorough analysis of scientific and pedagogical sources devoted to the applied focus of the «Advanced Mathematics» course. Issues related to the professional orientation of mathematical training for specialists in various fields are the focus of attention for numerous scholars. The methodological aspects of training economists have been thoroughly researched in the works of Bondarenko Z. V., Kyrylaschuk S. A. [1], Hotynchan I. Z., and Drin I. I. [2], while the issue of adapting the content of mathematical disciplines for humanities majors has been studied by Arshava O. O. [3]. The authors Korolyuk O. M., Lenchuk I. G., Mikhailenko V. V., Mosiyuk O. O., Prus A. V., Sverchevska I. A., Fonaryuk O. V., and Chemerys O. A. have examined the prospects and priorities of mathematics education in an era of social challenges in their research [4].

According to Z. I. Slepkan, «the effectiveness of mathematics instruction for future professionals depends on how successfully the instructor can reveal the practical application of mathematical concepts, transforming abstract formulas into tools for solving professional problems» [5]. The issue of improving the effectiveness of the educational process in the context of modern challenges through the use of innovative technologies is examined by specialists I. G. Hevlich and L. L. Hevlich [6]. A classification of economic problems based on the complexity of the corresponding mathematical models is presented by K. E. Rumyantseva [7]. Therefore, the training of future specialists is viewed through the lens of incorporating applied problems, and professionally oriented problems serve as a form of synthesis between theoretical knowledge and practical skills, determining the teaching methodology and the structure of the educational process as a whole. Sukhomlinova O. V., Geseleva K. G., and Dumanska T. V. examine the significance of interdisciplinary connections in higher mathematics and the ability to solve applied problems, and substantiate the necessity of mastering mathematical modeling as a universal method for solving practical problems [8].

The researchers' works provide a detailed description of the principles for selecting applied problems and establishing criteria for their solution. They analyze how to combine traditional classroom instruction with online technologies specifically for economists and how to transform complex mathematical abstractions into applied problems. Particular attention is paid to the development of professional competencies through the solution of practical problems that integrate the theoretical foundation with future professional activities, as well as to the issue of modernizing contemporary education and justifying the prospects and priorities of mathematics education in an era of social challenges.

The ***aim*** of this article is to substantiate an integrated approach to teaching mathematics through applied problems and digital tools.

Presentation of the main content and substantiation of the research findings. The relevance of this study stems from the need for a fundamental transformation of the educational process in Ukrainian higher education amid the unprecedented challenges posed by martial law. Constant threats to energy infrastructure and electric power blackouts require a shift from synchronous learning to flexible asynchronous models based on LMS platforms. In this context, higher mathematics for students pursuing a degree in «Management» must transform from a theoretical discipline into an applied tool for crisis management, supported by artificial intelligence technologies. Amid the rapid development of generative artificial intelligence and the digitalization of higher education, traditional approaches to teaching mathematical disciplines are losing their effectiveness. The relevance of this topic lies in the development of a methodology for teaching «Advanced Mathematics», where the applied nature of the problems allows students to master the mathematical modeling skills necessary for working with big data. The use of AI as an assistant in solving applied problems is becoming a key factor in training competitive managers.

The national standard for higher education in the D3 program in «Management» sets strict requirements for learning outcomes, many of which depend directly on the quality of mathematical training. A manager must be able to solve complex specialized problems and practical issues characterized by their complexity and uncertain conditions.

Thus, as noted by Bondarenko Z. V. and Kyrylaschuk S. A., «the effectiveness of teaching students in economics programs largely depends on the selection of professionally oriented mathematical problems with an economic component, on how they are designed, and on the methods used to work with them. Professionally oriented mathematical problems with an economic component are understood as problems whose content is related to the objects and processes of the student's future professional activity, and their investigation using mathematical tools contributes to the conscious application of mathematical knowledge during the study of specialized disciplines and the development of professional competence in future economists» [1].

Mathematical tools are an indispensable part of a modern economist's professional practice, essential for solving a wide range of applied problems. Efficient research into economic phenomena and processes involves the construction of mathematical models, the application of quantitative methods of data analysis, and the use of modern computational technologies.

The defining concepts of the competency-based approach in education are «competence» and «competencies», which are actively and extensively explored in educational science. The development of the competency-based approach in education began in the 1950s as a response to society's demand for the practical application of acquired knowledge. A results-oriented focus is a key feature of this method, as it emphasizes the acquisition of applied skills and abilities. In this regard, a pressing task is the theoretical substantiation and systematization of professional competencies that will ensure efficient interaction between the specialist and the surrounding environment. That is why it is important to understand what competence is, what exactly defines it, which specific competencies need to be developed, and what the learning outcome should be.

The EU Council Recommendation (May 2018) identifies eight key competences that are essential for the success of modern individuals. This Recommendation serves as a reference tool for stakeholders in the field of education and training, outlining a common understanding of the competences needed today and in the future. The recommended framework is based on successful methods of encouraging individuals to develop competencies through innovative approaches to learning, assessment methods, or support for educators [9]. This model of lifelong learning combines career opportunities with personal well-being, environmental awareness, and social responsibility. European researchers believe that the acquisition of knowledge, skills, and abilities aimed at improving one's competencies contributes to the intellectual and cultural development of the individual and helps them respond effectively to the demands of the times.

According to the EU Council Recommendation (2018), eight key competencies are identified:

1) Proficiency in the mother tongue (literacy): the ability to communicate effectively, interpret concepts, and express ideas both orally and in writing.

2) Multilingualism: knowledge of foreign languages, the ability to understand other cultures, and to communicate in an international environment.

3) Mathematical competence and skills in science, technology, and professional activities (STEM):

the ability to use mathematical thinking, understand the natural world through scientific methods, and apply technology to solve problems.

4) Digital competence: confident and critical use of digital technologies for learning, working, and participating in public life (including information literacy and safety).

5) Personal, social, and learning competence: the ability to engage in lifelong learning, manage one's own development, work in a team, and maintain physical and emotional well-being.

6) Civic competence: knowledge of socio-political conceptions, active participation in democratic life, and an understanding of European values.

7) Entrepreneurship: the ability to turn ideas into action through creativity, strategic planning, project management, and risk assessment.

8) Cultural awareness and expression: an understanding of the importance of art and culture, as well as the ability to creatively express one's own ideas through various forms of media and art.

These eight components form a comprehensive system: from basic literacy and digital skills to the ability to be a proactive and responsible citizen. Particular emphasis is placed on lifelong learning, which enables professionals to remain competitive in a dynamic world.

The EU recommendation emphasizes a positive attitude toward mathematics. This involves overcoming a fear of numbers and recognizing that mathematics is a tool for understanding the world, not merely an academic subject.

According to the EU Recommendation, «Mathematical competence is the ability to develop and apply mathematical thinking and knowledge to solve a variety of problems in everyday situations». When developing arithmetic skills, it is necessary to focus on the process and activities, as well as on knowledge. Mathematical competence involves, to varying degrees, the ability and willingness to use mathematical ways of thinking and presentation (formulas, models, constructions, graphs, diagrams)» [9].

The structure of mathematical competence can be described as follows:

- *procedural knowledge:* mastery of the language of numbers, symbols, and operations. This constitutes the basic tools (arithmetic, algebra, geometry);
- *mathematical thinking:* the ability to construct logical chains, prove statements, identify key points, and distinguish between facts and assumptions;
- *modeling reality:* the ability to translate a problem from everyday life into the language of mathematics, solve it, and interpret the result back into a real-world context;
- *statistical literacy:* working with data, graphs, and charts; understanding probabilities and risks, which is critically important in the information age.

In short, mathematical competence is much more than just the ability to count. According to European standards, it is the foundation for critical thinking and analysis. «A person must be able to apply fundamental mathematical principles and processes in everyday situations at home and at work (for example, having financial skills), as well as be able to follow and evaluate lines of reasoning. People should think mathematically, understand mathematical proofs and communicate in mathematical language, use appropriate tools, including statistical data and graphs, and understand the mathematical aspects of digitalization» [9].

In management, mathematical competence transforms from theoretical formulas into a concrete tool for managerial decision-making. For today's manager, this is not merely a matter of «calculations», but the ability to see the structure of a business through data.

Mathematical tools form the foundation for developing competencies such as analytical ability, decision justification, and organizational design.

Analytical ability is the skill of analyzing an organization's performance and comparing it with external and internal factors. Mathematics provides the tools for such comparisons through correlation and regression analysis and the construction of multivariate models.

Decision justification is the ability to identify problems and justify managerial decisions based on the calculation of metrics. Here, higher mathematics transitions into the realm of quantitative management methods.

Organizational design is the skill of designing business processes, which requires an understanding of network models, graph theory, and linear programming methods.

It is important to emphasize that mathematics fosters intellectual honesty and objectivity. Managerial decisions based on data and objective models are less susceptible to cognitive biases, which is critical for leadership in modern organizations.

Among the areas where mathematical competence is applied in management, the following can be highlighted:

- data analysis and forecasting (a manager must be able to identify patterns in past sales or performance results in order to plan for the future);

- financial management and budgeting (this is the foundation of any management, as mathematical literacy allows one to: calculate the break-even point; assess project profitability and payback periods; control expenses and optimize the tax burden);
- resource optimization (mathematics helps managers effectively allocate limited resources (time, people, raw materials)).

It can be concluded that mathematical competence makes a manager rational. It allows them to justify their position to owners or investors using the language of numbers, which is universal in business.

Today, professional competence as an economist is impossible without the use of mathematical modeling and quantitative analysis. The use of mathematical tools and computing technology allows complex economic phenomena to be transformed into clear models, ensuring the accuracy of calculations and the soundness of managerial decisions.

The popularity of input-output models in economics stems from their versatility in solving balance sheet problems. They allow for the clear structuring of data on production and the distribution of goods among industries or divisions. The main tool here is the input-output method (Leontief model), which uses a matrix form to illustrate the transformation of resources into finished products. It shows how different sectors of the economy interact with one another, consuming the output of neighboring sectors to produce their own. From the perspective of mathematical tools, matrix operations allow not only for grouping data (addition) but also for analyzing complex interdependencies within organizational structures (multiplication), making this branch of mathematics critically important for the training of future economists.

As an example, let's consider a practical case study: «The Three-Sector Economic Model».

Suppose the economy of a certain region consists of three interconnected sectors: manufacturing, agriculture, and energy. The direct cost matrix looks like this:

$$A = \begin{pmatrix} 0.3 & 0.2 & 0.2 \\ 0.1 & 0.4 & 0.2 \\ 0.3 & 0.1 & 0.2 \end{pmatrix}.$$

The matrix describing the internal needs of the sectors is as follows:

$$Y = \begin{pmatrix} 250 \\ 100 \\ 180 \end{pmatrix}.$$

The manager must calculate the total volume of output for each product type in order to fulfill market orders while simultaneously meeting the raw material needs of all three industries.

The educational value of this example lies in the fact that it clearly demonstrates:

- *professional competence* (the student sees that the economy is a networked structure, so increasing the production plan in one sector automatically requires recalculating plans in other sectors);
- *mathematical precision* (it is impossible to calculate this chain effect manually without using matrix calculations);
- *decision-making* (a manager can simulate any situation. For example, the matrix will immediately show how the cost of production in the «Industry» and «Agriculture» sectors will change if the price of energy resources rises by 8%).

Let's look at some more practical examples of matrix calculus in action.

PRACTICAL CASE STUDY: «COST CALCULATION FOR A FURNITURE FACTORY»

A furniture factory manufactures two types of products: tables and chairs. The raw material costs (wood and varnish) for producing one unit of each product type are presented in the form of a matrix:

$$A = \begin{pmatrix} 6 & 3 \\ 2 & 0.8 \end{pmatrix}.$$

The monthly production plan for the factory is presented in the form of a matrix

$$B = \begin{pmatrix} 40 \\ 160 \end{pmatrix}.$$

The manager needs to determine the amount of raw materials required to fulfill the production plan and the cost of such an order.

The educational value of this example lies in the fact that it clearly demonstrates the learning function (the learner sees that matrix multiplication is not just an abstract exercise, but a way to instantly consolidate complex data into a single result); the development function (the future manager learns to think in terms of «data sets», and if the order changes, they do not need to recalculate everything manually – it is enough to change the numbers in the matrix *B*, and the system (for example, if calculations are done using MS Excel) will immediately produce the result); scalability (if a factory has the capacity to produce a large number of product SKUs and uses a wide variety of raw materials for this purpose, the use of a matrix calculation tool significantly simplifies the calculation process).

Let's look at a few more practical case studies that illustrate various aspects of a manager's work.

PRACTICAL CASE STUDY: «LOGISTICS AND TRANSPORTATION NETWORK»

Three logistics centers are considered. We need to calculate the cost of delivery between them, given that the cost matrix looks like this:

$$C = \begin{pmatrix} 0 & 150 & 200 \\ 150 & 0 & 100 \\ 200 & 100 & 0 \end{pmatrix}.$$

Given a matrix of cargo volumes, it is easy to calculate the total logistics budget by multiplying the matrices.

PRACTICAL CASE STUDY: «INVESTMENT PORTFOLIO ANALYSIS»

The company invests in three types of assets: stocks, bonds, and real estate. The manager needs to decide where it is more profitable to invest the company's funds, given an investment matrix $S = (15\ 10\ 5)$ showing the amount (in UAH millions) invested in each asset, and a return matrix

$$R = \begin{pmatrix} 0.1 & 0.04 & 0.07 \\ 0.05 & 0.06 & 0.09 \\ 0.12 & 0.03 & 0.11 \end{pmatrix},$$

which shows the profit percentage over three years (2023, 2024, 2025).

Each column represents a specific asset, and each row represents a specific year.

By multiplying the investment matrix by the transposed matrix of the return matrix, the manager will obtain a matrix of dimension , each element of which represents the total profit of the entire company for a specific year.

Let's consider another practical example: human resources management (HR management).

The company has three open positions for which candidates need to be selected. The HR manager conducts a competitive selection process based on three criteria (experience, performance on a test task, and teamwork).

The evaluation matrix is provided as follows

$$K = \begin{pmatrix} 3 & 5 & 4 \\ 4 & 3 & 5 \\ 5 & 4 & 3 \end{pmatrix},$$

where the candidates correspond to the rows of the matrix, and the criteria (in the form of scores) correspond to the columns. There is also a priority matrix

$$P = \begin{pmatrix} 0.2 \\ 0.5 \\ 0.3 \end{pmatrix}.$$

By multiplying the evaluation matrix by the priority matrix, the manager obtains a final ranking for each candidate. This makes the hiring process mathematically sound and transparent, eliminating subjectivity.

The educational value of these examples lies in the fact that they demonstrate universality (matrices work with money, people, and goods alike) and foster systems thinking (the manager sees not an individual employee or machine, but an interconnected structure).

Incorporating these examples into the educational process allows for the realization of the key functions of education (developmental, instructional, formative, and evaluative) through the lens of a competency-based approach.

Working with matrices helps students develop structural thinking. They learn to view business not as a series of random events, but as a system of linear dependencies. This fosters the ability to quickly analyze large datasets (*Developmental function*).

Students master specific mathematical tools (the Leontief model, matrix addition and multiplication) not as abstract formulas, but as ready-made algorithms for solving real economic problems: from calculating production costs to optimizing logistics (*Educational function*).

Working on such cases fosters responsibility for the decisions made. When a student sees how an error in matrix calculation leads to a shortage of raw materials or losses in the model, they realize the value of accuracy and professional integrity (*Educational function*).

Solving practice-oriented problems is the best indicator of whether the student has mastered the material. This allows the instructor to assess not only how well the student has memorized formulas, but also the level of development of professional competence – that is, the ability to apply advanced mathematics in management activities (*Assessment function*).

For managers, analytical geometry is not just the study of points and lines, but also a powerful tool for visualizing business processes and optimizing resources. Within the competency-based approach, this branch of mathematics helps transform dry numbers into graphical models that are easier to analyze and present.

For example, the break-even point is a fundamental concept in financial management that is entirely based on analytical geometry.

Let's consider a **practical case study: «Startup Survival Analysis»**.

To launch and operate a café, you need to account for fixed costs (rent, employee salaries, and utility bills) and variable costs (the cost of ingredients for food and drinks, the cost of disposable tableware, and so on). The cost of each serving is also known. It is necessary to calculate the minimum revenue required so that the café does not operate at a loss.

To solve this problem, the student must plot the total cost function and the total revenue function, find the break-even point, and draw a conclusion.

This problem fulfills an educational function (the student applies knowledge of linear functions and systems of equations in practice), an analytical function (the manager identifies the boundary between loss and profit), and an entrepreneurial competency (the ability to assess the viability of a business idea before opening the establishment).

Marketing positioning using perceptual maps is a vivid example of how analytical geometry tools (the Cartesian coordinate system) help a manager visualize the competitive environment and strategically plan brand development.

A perception map is a two-dimensional graph on which products or brands are represented as points with coordinates. The coordinate axes are chosen based on the key characteristics by which consumers compare products.

Let's consider a **practical case study: «Choose a Drink».**

An analysis is being conducted of the market entry of two popular beverages: Guarana (an energy drink based on guarana extract) and Sumol (a fruit-flavored carbonated beverage). We need to determine their market position relative to competitors using the perception map method.

To solve this problem, we will use the results of a marketing survey on two scales from 0 to 10:

axis *OX* (energy) – from «calming» (0) to «maximum energy» (10);

axis *OY* (naturalness) – from «artificial taste» (0) to «natural» (10).

Object coordinates on the plane:

Guarana – high energy level, medium-high naturalness *G* (9, 6).

Sumol – low energy (refreshing), very high naturalness (juice) *S* (2, 10).

Competitor 1 (Red Bull) – maximum energy, low naturalness *R* (10, 2).

Competitor 2 (Fanta) – low energy, low naturalness *F* (2, 3).

The student must construct a Cartesian coordinate system and plot these four points on the plane: (9, 6), (2, 10), (10, 2), (2, 3) (*Fig. 1*).

To calculate the competitive distance, we need to apply the well-known formula for the distance between two points $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ and calculate the distance between the points corresponding to the drinks «Guarana» and «Red Bull», and «Sumol» and «Fanta».

Distance between the points *G* and *R*:

$$d = \sqrt{(10-9)^2 + (2-6)^2} = \sqrt{1+16} = \sqrt{17} \approx 4{,}12.$$

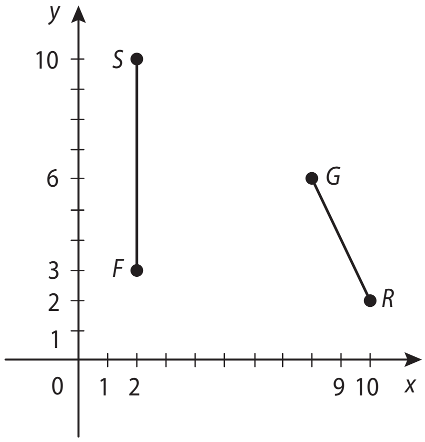

Fig. 1. Graphical solution to the problem

Distance between the points *S* and *F*:

$$d = \sqrt{(2-2)^2 + (3-10)^2} = \sqrt{0+49} = \sqrt{49} = 7.$$

Since the distance between the points *G* and *R* is less than the distance between the points *S* and *F*, we can conclude that Guarana is in a more intense competitive zone. Therefore, the Guarana manager will have to compete more actively for customers who specifically want a high-energy drink. Sumol, on the other hand, is positioned furthest from the non-natural drinks. Its unique selling proposition is based on high naturalness combined with low energy.

The use of this problem in a college-level mathematics course for managers serves an educational function (students learn the algorithm for calculating distances in n-dimensional space (in this case, $n = 2$)), a developmental function (developing interpretive competence – the ability to explain a mathematical result (the number 4.12 – the level of market threat)), and an educational function (fostering an objective approach to marketing. Instead of saying «we are better than our competitors», the future manager learns to say «our distance from the nearest competitor is 7 units, which gives us room to maneuver».

This example perfectly illustrates how analytical geometry transforms into a tool for visual analytics. It is precisely this approach that makes learning professionally oriented, facilitates a deep understanding of abstract mathematical concepts through their applied value, and meets the requirements for training the next generation of managers.

The use of differential calculus in professional management training involves a shift from simply describing the state of a system to analyzing the rate of change and finding extrema. In economics, it is often necessary to determine the optimal value of a particular indicator, such as maximum profit, minimum costs, or maximum labor productivity. Each indicator depends on one or more variables. Such problems constitute a separate class, and methods of differential calculus are used to solve them.

Let's consider three main practical cases that reveal the potential of derivatives in economics and management.

PRACTICAL CASE STUDY: «PROFIT MAXIMIZATION»

The function relating total revenue (TR) to output (*q*) is given by: $TR(q) = 100q - 2q^2$, and the total cost (TC) function is given by: $TC(q) = q^3 - 10q^2 + 40q + 50.$ Determine the output level at which the firm's profit is maximized.

To solve this problem, you need to derive the profit function $\pi(q) = TR(q) - TC(q)$, find the marginal profit $(\pi'(q))$, and, by setting it equal to zero, calculate the critical points.

As a result of solving this case study, the student learns to understand that profit reaches its maximum value when marginal revenue equals marginal cost.

PRACTICAL CASE STUDY: «MARKET SENSITIVITY ANALYSIS»

In the practical case study «Choose a Beverage», we analyzed the market position of each beverage relative to its competitors. Now, suppose we are given the demand function for a beverage as a function of price (*p*): $y = \frac{500}{p+2}$. We need to calculate the price elasticity of demand at a price of *p* = 40 UAH and explain whether the manager should raise the price to increase revenue.

To solve this problem, use the formula for calculating price elasticity:

$$E_p(y) = \frac{p}{y} \cdot y'.$$

After performing the calculations, the manager can conclude: if $|E_p(y)| > 1,$ then demand is elastic and raising the price will lead to a significant drop in sales. If $|E_p(y)| < 1,$ then demand is inelastic, so the price can be raised. This teaches the future manager to make informed decisions regarding pricing.

PRACTICAL CASE STUDY: «INVENTORY MANAGEMENT»

Let's consider the Wilson model – a classic mathematical model in logistics that determines the optimal order quantity to minimize total costs associated with purchasing and storing inventory.

A logistics manager must minimize the total costs of ordering and storing goods in the warehouse. Total costs are described by the function: $L(x) = \frac{a}{x} + bx,$ where *x* is the batch size, *a* is the ordering cost, and *b* is the storage cost per unit of goods. Find the optimal batch size at which total costs are minimized.

To solve this problem, we need to examine the total cost function for extrema. That is, calculate its derivative $L'(x) = -\frac{a}{x^2} + b,$ set it equal to zero, find the critical points, and check them for extrema.

Thus, it can be argued that the use of these problems in a college-level mathematics course for managers also serves an educational function (the student masters the technique of differentiation not as an abstract exercise, but as a method for finding the optimal solution), a developmental function (dynamic thinking is fostered, since a manager must understand how quickly profit will change if the price changes), and an educational function (it develops a rational approach to resources; thus, mathematics demonstrates that «producing more» does not always mean «earning more» (there is an optimal point)).

Integration has a wide range of applications in economics. For example, it is used to determine cost, profit, or consumption functions, provided that the corresponding marginal cost, marginal profit, and marginal consumption functions are known. To determine an arbitrary constant, an additional condition is required. When finding the cost function, the following condition is applied: if output *x* = 0, then the value of the cost function equals fixed costs, whereas when finding the profit function, a different condition is used: if output *x* = 0, then the value of the profit function equals zero (if the product is not sold, there is no profit) [10].

The use of integral calculus in management training allows us to move beyond analyzing instantaneous changes (as derivatives do) to summarizing results and assessing the cumulative effect over a specific period.

Let's consider some practical case studies that involve the concepts of indefinite and definite integrals.

PRACTICAL CASE STUDY: «OPTIMIZING BEVERAGE PRODUCTION»

Suppose that the marginal cost of producing a batch of energy drink is described by the following function: $MC(q) = 6q + 40,$ where *q* is the number of thousand liters; fixed costs amount to UAH 20 000, and the marginal revenue from the sale of each additional thousand liters of the drink decreases according to the function $MR(q) = 100 - 4q.$

We need to find the total cost and total revenue functions; calculate the revenue the company will receive from selling 20 000 liters of the beverage.

To find total costs, we must integrate the function describing marginal costs.

Therefore,

$$TC(q) = \int (6q + 40)\, dq = 3q^2 + 40q + C.$$

Since fixed costs are 20 000, then when q = 0, C = 20 000.

Then, $TC(q) = 3q^2 + 40q + 20000$ and the production cost of 20 000 liters of the beverage is UAH $TC(20) = 3 \cdot 20^2 + 40 \cdot 20 + 20\,000 = 22\,000$.

And total revenue is the integral of marginal revenue:

$$TR(q) = \int (100 - 4q)\, dq = 100q - 4q^2 + C.$$

Since revenue is 0 when 0 units are sold, C = 0, so the revenue function is: $TR(q) = 100q - 4q^2$.

If q = 20, then

$TR(20) = 100 \cdot 20 - 4 \cdot 20^2 = 2000 - 1600 = 400$ UAH.

Now the manager can assess the financial result. To do this, they need to calculate the total profit $TR - TC$ = 400 – 22,000 = –21 600 UAH and conclude that producing 20 000 liters at these fixed costs is unprofitable. Integration has made it possible to see the «big picture», which was not apparent from the marginal figures alone. The manager needs to either increase production volume or reduce fixed costs.

CASE STUDY: «LAUNCHING A NEW BEVERAGE BOTTLING LINE»

When launching the production of a new product, managers face many questions, the answers to which can be found using integral calculus. Typically, functions of the form $f(x) = ax^b$ are used, where a is the time spent on the first unit (a > 0), and b is a measure of the production process $(-1 \le b < 0)$. This function is decreasing because the time required to perform a specific operation, repeated several times, decreases as the number of repetitions increases. The graph of such a function is called a learning curve. From an economic perspective, the learning curve is a conception that describes how the time or labor costs per unit of output decrease as workers gain experience. It is an extremely important tool for managers when planning work schedules, budgeting, and evaluating staff performance.

So, the company plans to launch a new beverage bottling line. It is known that, due to the learning curve, the time required to process each subsequent thousand liters decreases, and the time-cost function (in hours) is as follows: $f(x) = 15 \cdot x^{-0.5}$.

The manager needs to calculate how much total time (man-hours) the team will need to produce the first 5 000 liters of the beverage.

To solve this problem, the student must find the total time. To do this, first, calculate the initial value of the time function, and then find the value of the definite integral over the interval [0, 5].

We can also consider the practical case of «Economic Welfare», where economic welfare is a comprehensive indicator that reflects the total benefit derived by all market participants (both buyers and sellers) from commercial transactions. In mathematical terms, it is the sum of consumer surplus and producer surplus. For a manager, it is a tool that allows them to assess how changes in prices, taxes, or subsidies affect the market as a whole.

In other words, incorporating practical problems involving integral calculus into the educational process transforms the study of mathematics from a purely theoretical obligation into practical training for future managers and serves an educational (the learner learns to reconstruct the whole from its parts – the transition from local indicators to global strategic results), developmental (it fosters predictive thinking, since a future manager must be able to calculate the future value of assets or total risks based on current dynamics), and educational (understanding the compounding effect, as mathematics demonstrates that small daily expenses or profits collectively form significant capital (fostering financial literacy)) functions.

CONCLUSION

As many years of experience have shown, one of the key factors in the successful training of future economic professionals is strengthening the mathematical component of economic education and providing students with a solid mathematical foundation – specifically, mastering fundamental mathematical knowledge and skills, developing rational mathematical thinking, and fostering a culture of mathematical literacy. A key element of this transformation is the introduction of applied problems, which serve as a bridge between abstract mathematical conceptions and the real challenges of managerial activity.

A modern economist must be proficient in contemporary economic-mathematical methods and be able to use them to model real economic situations, as this will allow them to better grasp the theoretical aspects of modern economics and contribute to enhancing the specialist's professional qualifications and overall professional culture.

The implementation of this system of problems not only ensures an educational effect (the ability to apply mathematics in economics) but also plays an important developmental and formative role, shaping independent professionals with well-developed analytical thinking. At the same time, it serves as a reliable mechanism for diagnosing and monitoring students' educational achievements.

Today, a manager's mathematical training is viewed not merely as mastering a set of computational algorithms, but as developing a specific analytical toolkit that allows for the formalization of complex socio-economic systems and the making of informed decisions under conditions of high uncertainty. ■

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