УДК 378.65.011.56 doi: 10.20998/2220-4784.2025.01.06

***O. P. PRISHCHENKO, T. T. CHERNOGOR***

## FEATURES OF THE USE OF INTEGRALS FOR SOLVING PROBLEMS WITH PHYSICOCHEMICAL CONTENT

The article considers some examples of application of integrals, which can be used in practical classes in higher mathematics, teaching students of chemical specialities. Examples of problems with physical and chemical content are given. Most often, when studying the course of higher mathematics it is necessary to solve problems of general character. But for the students of the Training and Research Institute of Chemical Technologies and Engineering the tasks that are directly related to their speciality are of greater interest. Thus, by considering the tasks such as those given in this article, we will increase the interest and motivation of future specialists to study this material. Also, when applying complex training sessions, students form and develop professional competences that allow them to perform engineering research work on specific technological processes. When solving many problems of both applied and theoretical nature it is necessary to sum up an infinite number of infinitesimal summands. This operation leads to one of the central concepts of mathematical analysis - the concept of integral (or definite integral). The definite integral is widely used in numerous applied mathematical and physical problems. For example, the application of the definite integral in geometric problems shows itself when solving problems to find areas of plane figures and surfaces that have complex shapes. The definite integral is applicable for finding the volume of a body of rotation, a body of arbitrary shape, as well as for finding the length of a curve, both in the plane and in space. The definite integral is used to calculate statistical moments, masses and centres of masses for arbitrary curves and surfaces in physics and theoretical mechanics problems. It can also be applied in calculating the work of force along a given path and other problems.

**Keywords:** integral, definite integral, mathematical analysis, mathematical model, differential equation, laminar flow, Poiseuil's law.

***О. П. ПРІЩЕНКО, Т. Т. ЧЕРНОГОР***

## ОСОБЛИВОСТІ ВИКОРИСТАННЯ ІНТЕГРАЛІВ ДЛЯ РОЗВ'ЯЗАННЯ ЗАДАЧ З ФІЗИКО-ХІМІЧНИМ ЗМІСТОМ

У статті розглянуто деякі приклади застосування інтегралів, які можна використовувати на практичних заняттях з вищої математики, навчаючи студентів хімічних спеціальностей. Наведено приклади задач із фізико-хімічним змістом. Найчастіше, під час вивчення курсу вищої математики доводиться розв'язувати задачі загального характеру. Але для студентів Навчально-наукового інституту хімічних технологій та інженерії більший інтерес становлять задачі, які безпосередньо пов'язані з їхньою спеціальністю. Таким чином, розглядаючи задачі, подібні до наведених у даній статті, ми підвищимо інтерес і мотивацію майбутніх фахівців до вивчення даного матеріалу. Також, при застосуванні комплексних навчальних занять відбувається формування і розвиток у студентів професійних компетенцій, що дозволяють їм виконувати інженерно-дослідницьку роботу за конкретними технологічними процесами. Під час розв'язання багатьох задач як прикладного, так і теоретичного характеру доводиться підсумовувати нескінченну кількість нескінченно малих доданків. Ця операція приводить до одного з центральних понять математичного аналізу – поняття інтеграла (або визначеного інтеграла). Своє широке застосування визначений інтеграл знаходить у численних прикладних математичних і фізичних задачах. Наприклад, застосування визначеного інтеграла в геометричних задачах проявляє себе під час розв’язування задач на знаходження площ плоских фігур і поверхонь, які мають складні форми. Визначений інтеграл застосовується для знаходження об’єму тіла обертання, тіла довільної форми, а також для знаходження довжини кривої, як на площині, так і в просторі. За допомогою визначеного інтеграла обчислюють статистичні моменти, маси і центри мас для довільної кривої і поверхні в задачах фізики і теоретичної механіки. Також він може бути застосований при обчисленні роботи сили по заданому шляху та інших задач.

**Ключові слова:** інтеграл, визначений інтеграл, математичний аналіз, математична модель, диференціальне рівняння, ламінарна течія, закон Пуазейля.

**Introduction.**

The development of chemical technology is associated with the creation of new highly efficient processes and modernization of existing technological installations.

This task can be successfully solved using the method of mathematical modeling, which allows to study the properties of objects on mathematical models, to carry out computer forecasting of optimal schemes and modes of operation of industrial plants, to develop automated control systems of technological processes.

It is natural that a modern specialist should know the methods of mathematical analysis, possess the latest means of analysis and synthesis of chemical-technological systems with the use of computer technologies [1].

The main purpose of teaching the academic discipline "Higher Mathematics" is to prepare students to use modern mathematical apparatus as an effective tool for solving scientific and practical problems in the field of chemical and related disciplines.

In chemical technology are widely represented processes characterized by a complex composition of the reacting mixture, a large number of simultaneously occurring reactions and mutual transformations. Such processes are fundamental in oil refining and petrochemistry, in the processing of secondary resources, and in the production of products by thermal destruction of solid fuels.

Mathematical modeling of such processes is associated with significant difficulties due to the multicomponent nature and lack of study of the detailed mechanism. Mathematics acts as a tool for solving these problems. The course of higher mathematics is the basis of physical and mathematical training of university chemistry specialists [1-5].

**Statement of the problem in general and its connection with important scientific or practical problems**

In solving many problems of both applied and theoretical nature, it is necessary to sum an infinite number of infinitesimal summands. This operation leads to one of the central concepts of mathematical analysis - the concept of integral (or definite integral).

The definite integral is widely used in numerous applied mathematical and physical problems.

For example, the application of the definite integral in geometric problems shows itself when solving problems to find areas of plane figures and surfaces that have complex shapes. The definite integral is applicable for finding the volume of a body of rotation, a body of arbitrary shape, as well as for finding the length of a curve, both in the plane and in space.

Using the definite integral, statistical moments, masses and centers of masses for arbitrary curves and surfaces are calculated in problems of physics and theoretical mechanics. It can also be applied in calculating the work of force along a given path and other problems.

The purpose of mathematical training of students of chemical specialties is to familiarize them with the basic concepts and methods of modern mathematical apparatus as a means of solving problems of physical, chemical, biological and other nature, encountered both in the study of specialized disciplines and in further professional activity.

This article is devoted to examples of using integrals to solve problems with physical and chemical content in practical classes in higher mathematics.

**Presentation of the main research material.**

***THE BOEGER–LAMBERT–BEER LAW***

Let a beam of light of intensity $I_0$ pass through a layer of solution containing an absorbing substance with concentration $c$. Then, as a result of optical absorption, the intensity of the whole flux will decrease, and the decrease in intensity $\Delta I$ when passing through a layer of thickness $\Delta x$ is proportional to the product of the thickness of this layer, the concentration of the absorbing substance and the light intensity, i.e.

$$\Delta I = \alpha c I \Delta x, \qquad (1)$$

where $\alpha > 0$ is the absorption coefficient.

Based on the optical absorption property, we can obtain the relationship between the intensity of the light flux $I_0$ at the input of the cuvette with absorbing solution and the intensity of the light flux $I$ at the output. For this purpose, we proceed as follows.

Let us denote by $\Delta I$ the decrease in the intensity of the light flux passing through the layer with thickness $\Delta x$ i.e.

$$\Delta I ::= I\left(x+\Delta x\right) - I\left(x\right) < 0,$$

where $\Delta I$ is determined by formula (1).

Equality (1) can be written in the differential form, taking into account that the absorption coefficient $\alpha > 0$:

$$dl = -\alpha c I dx.$$

If we assume that the solution sample is homogeneous and the concentration $c$ does not depend on $x$, the last equality can be rewritten as

$$d\left(\ln I\right) = -\alpha c dx.$$

i.e., the simplest differential equation is obtained.

Integrating this equation taking into account that the thickness of the cuvette is equal to $l$,

$$\int_{I_0}^{I(l)} d\left(\ln t\right) = -\int_0^l \alpha c dx.$$

we obtain the ratio

$$I\left(l\right) = I_0 \exp\left(-\alpha c l\right), \qquad (2)$$

which is an analytical expression of the Bouguer–Lambert–Beer law that determines the magnitude of optical absorption in a sample of finite thickness [6-10].

*Task.* Taking into account the Bouguer–Lambert–Beer law, find the expression for the optical density $D ::= \lg \dfrac{I_0}{I}$.

Decision. Logarithmizing equation (2), we obtain

$$\lg I\left(l\right) = I_0 - \alpha c l, \text{ или } \lg \frac{I_0}{I} = \alpha c l.$$

Introducing the value $D ::= \lg \dfrac{I_0}{I}$. (traditional characteristic of optical absorption), we obtain the following simple notation for the Bouguer–Lambert–Beer law:

$$D = \varepsilon c l,$$

where $\varepsilon ::= \alpha/2{,}303$ is the extinction coefficient, which characterizes the absorption capacity of a given substance at a given wavelength.

The Bouguer–Lambert–Beer law is widely used in spectrophotometric determination of the content of chemical substances in solutions.

## *VELOCITY OF LAMINAR FLOW OF LIQUID*

Consider a thin cylindrical tube of finite length. Suppose that a liquid characterized by some viscosity coefficient flows through it under the action of pressure difference at the inlet and outlet holes. Taking into account the symmetry of the cross-section of the tube, we can assume that the velocity of the liquid in all points equidistant from the wall is the same; the velocity at the wall due to the adhesion of the liquid to it is zero. In other words, the velocity at the liquid layer depends on its distance from the tube wall: $v = v(r)$. Such a flow is called *laminar flow*.

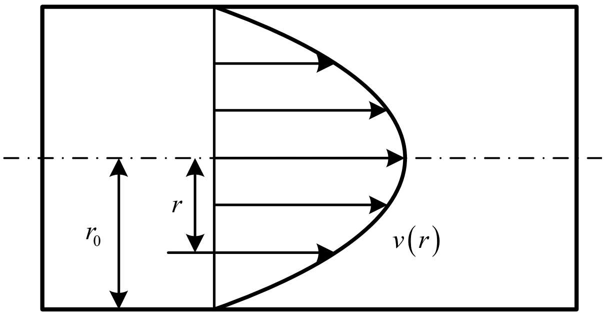


Fig. 1

So, laminar flow is an ordered flow in which a liquid or gas moves in layers parallel to the direction of flow. The scheme of homogeneous shear of liquid layers in the longitudinal section of a tube is shown in Fig. 1.

Newton's basic law of viscous flow, is as follows:

$$F = \eta \frac{v_2 - v_1}{r_2 - r_1} S\,, \tag{3}$$

where $F$ is the internal friction force; $S$ is the layer area; $v_1$ and $v_2$ are the velocities of the layers, respectively, lagging behind the tube wall at distance $r_1$ and $r_2$; η is the viscosity coefficient.

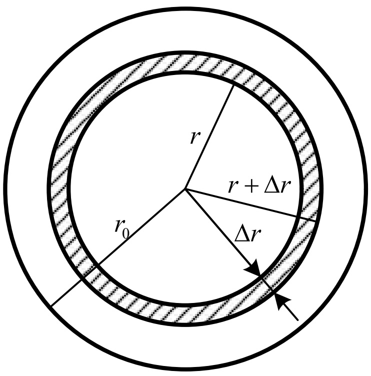


Fig. 2

Let the length of the tube be $l$ and the pressure at its inlet and outlet holes be $p$ and $p_0$, respectively. Based on the basic law of viscous flow (3), we obtain an expression for the flow velocity in differential form.

For this purpose, we select an elementary cylinder of length $\Delta l$ and radius $r$ in the tube. Change the radius by the value $\Delta r$ (see Fig. 2). This cylinder will experience friction, the force of which, according to law (3), will amount to

$$\Delta F = \eta \frac{\Delta y}{\Delta r} \Delta S,$$

where $\Delta S$ is the side surface area of the cylinder. Therefore

$$\Delta F = \eta \frac{\Delta y}{\Delta r} 2\pi r \Delta l,$$

The friction force is counteracted by the pressure force, which is equal to $\Delta F$ and opposite to it in direction, i.e.

$$\Delta F = -\pi r^2 \Delta P,$$

$\pi r^2$ – base area of the elementary cylinder; $P = p - p_0$

Equating the first parts of the last two expressions of the increment $\Delta F$, we obtain

$$\Delta v = -\frac{1}{2\eta} \frac{\Delta P}{\Delta l} r \Delta r.$$

Since the cross sections of the tube are the same along its entire length, the pressure in the tube is distributed uniformly and is equal to $\frac{p - p_0}{l}$. Therefore $\frac{\Delta P}{\Delta l} = \frac{p - p_0}{l}$.

So, uh.,

$$\Delta v = -\frac{1}{2\eta} \frac{p - p_0}{l} r \Delta r,$$

or in differential form

$$dv = -\frac{1}{2\eta} \frac{p - p_0}{l} r dr.$$

The simplest differential equation is obtained [11-14].

*Task.* Find the laminar flow velocity as a function of $r$ if the radius of the tube is $r_0$ and $v(r_0) = 0$.

D e c i s i o n . Integrating the last differential equation under the condition that $v(r_0) = 0$, we obtain

$$v = -\frac{p - p_0}{2\eta} \int_{r_0}^{r} \rho d\rho,$$

or finally

$$v = \frac{1}{4\eta}\frac{p - p_0}{l}\left(r_o^2 - r^2\right). \qquad (4)$$

*Remark.* The above reasoning and formula (4) are valid for normally viscous, so-called "Newtonian" fluids. If we consider, for example, discrete systems or polymer solutions, which are spatial structures formed by bonded particles or micromolecules, the above reasoning is not suitable. When such fluids flow, the work of the external force is spent not only to overcome the "Newtonian" viscosity, but also to destroy the structure.

### *POISEUILLE'S LAW*

Consider the flow of liquid through a thin tube of finite length and constant diameter under the action of pressure difference at its inlet and outlet holes. Since the diameter of the tube does not change, the velocity of the liquid at all points equidistant from the tube wall is the same. At the same time, the velocity at the wall due to adhesion of the liquid to it is zero. It is clear that in this case the flow velocity is a function of $r$, i.e. $v = v(r)$, where $r$ is the distance from the central axis of symmetry of the tube (see Fig. 2).

In the cross-section of the tube, let us select an elementary ring with radius $r$ and thickness $\Delta r$ (see Fig. 2) and find its area $\Delta D$ as the difference of the areas of two circles with radii $r + \Delta r$ and $r$.

$$\Delta D = \pi\left(r + \Delta r\right) - \pi r^2 = \pi\left(r^2 + 2r\Delta r + \Delta r^2\right) - \pi r^2 = 2\pi r\Delta r.$$

Then the volume of liquid $\Delta Q$, flowing through this ring in 1 s, will be equal to

$$\Delta Q = \Delta D v,$$

where $v$ is the laminar flow velocity.

Considering equality (4) and the value $\Delta D$, we obtain

$$\Delta Q = \frac{\pi}{2\eta}\frac{p - p}{l} r\left(r_0^2 - r^2\right)\Delta r,$$

or in differential form

$$\Delta Q = \frac{\pi}{2\eta}\frac{p - p_0}{l} r\left(r_0^2 - r^2\right)dr,$$

Thus, the differential equation describing the fluid flow from the tube is obtained [15–17].

*Task.* Find the volume of liquid flowing for 1 s through the cross-section of the tube, if the pressure $p$ at its inlet, pressure $p^0$ at the outlet of the tube, the diameter of the tube $d$ and length $l$, the viscosity coefficient of the liquid $\eta$ and the velocity $v$ of its laminar flow, given by formula (4), are known.

D e c i s i o n. If $r$ changes from 0 to $r^0$, then by the meaning of the problem $Q$ changes from 0 to $Q_0$. Integrating the last equation within the specified limits, we obtain

$$\int_0^{Q_0} dQ = \frac{\pi}{\eta}\frac{p - p_0}{l}\int_0^{r_0} r\left(r_0^2 - r^2\right)dr,$$

from where

$$Q_0 = \frac{\pi}{128}\frac{p - p_0}{l}\frac{d^4}{\eta}.$$

This formula expresses Poiseuille's law (discovered empirically in 1841), by which the volume of liquid flowing in 1 s through the cross-section of a thin tube is determined. The mathematical proof of this law is also given here.

*Note*. The obtained law of fluid flow through a thin cylindrical tube is valid for so-called "Newtonian" liquids, i.e., for such liquids that do not form particle or macromolecule cohesions causing a sharp increase in viscosity [18].

### *IONIZATION PROCESS IN A GAS MEDIUM*

When ionizing radiation particles pass through a gas medium, an equal number of positively and negatively charged ions are formed, which then gradually (and very quickly) interact with each other (recombine). In this case, the rate $v$ (ion -· $c^{-1}$) of change of ion concentration will be determined by the difference of the rates of formation (generation) $v_r$ and recombination $v_p$:

$$v = v_r - v_p. \qquad (5)$$

If we consider that the recombination reaction rate is proportional to the product of the concentrations of positively and negatively charged ions (equally of each), then

$$v_p = k_p\left(\frac{x}{2}\right)^2,$$

where $x$ is the total current concentration of ions in the gas medium; $k_p$ is the recombination reaction rate constant (ion$^2$ -· $c^{-1}$).

Writing equation (5) in differential form

$$\frac{dx}{dt} = v_r - k_p\frac{x^2}{4},$$

we obtain the simplest differential equation, which can be written in the form:

$$\frac{dx}{v_r - k_p \frac{x^2}{4}} = dt. \qquad (6)$$

*Task*. It is required to determine how the total concentration of ions in a gas medium changes with time $t$ when irradiated by a source of ionizing radiation, if at the initial moment of time at $t = 0$ the concentration $x = 0$.

D e c i s i o n . Let us rewrite equation (6) in the form

$$\frac{dx}{\alpha\left(a^2 - x^2\right)} = dt,$$

where

$$\alpha ::= \frac{k_p}{4} > 0, a^2 ::= \frac{v_r}{\alpha} > 0,$$

or after integration

$$t = \frac{1}{\alpha}\int_0^x \frac{dz}{a^2 - z^2}.$$

Decomposing the integrand $\frac{1}{a^2 - z^2}$ into the sum of simplest rational functions

$$\frac{1}{a^2 - z^2} = \frac{1}{2a\left(a+z\right)} + \frac{1}{2a\left(a-z\right)}$$

and finding the first variables, we obtain

$$t = \frac{1}{2\alpha a}\ln\frac{a-z}{a+z}\bigg|_0^x = \frac{1}{2\alpha a}\ln\frac{a-x}{a+z}.$$

So, uh.,

$$\frac{a+x}{a-x = e^{2\alpha at}},$$

whence (see Fig. 3)

$$x = a\frac{e^{2\alpha at} - 1}{e^{2\alpha at} + 1}.$$

From the obtained relation we can see that after some time a constant concentration of ionized particles is established in the system, since

$$\lim_{x\to+\infty} a\frac{e^{2\alpha at} - 1}{e^{2\alpha at} + 1} = a = 2\sqrt{v_r/k_p}.$$

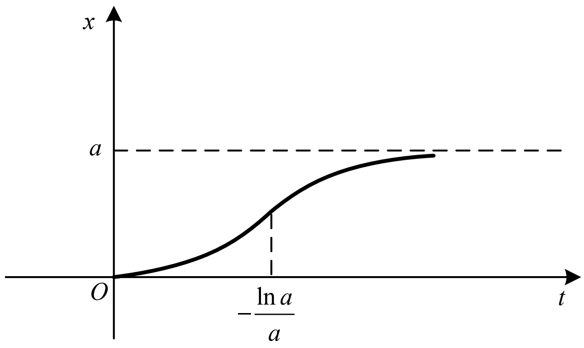


Fig. 3

***MEASUREMENT OF RADIATION FROM A POINT SOURCE OF RADIOACTIVITY***

Let a point radioactive source radiates uniformly in all directions. Then the points of equal intensity will lie on the sphere, in the center of which the radiation source is located (Fig. 4).

A Geiger counter, which is in the form of a tube, captures some of the radiation through an inlet opening of a certain diameter. The efficiency of such capture is characterized by the geometric factor $G$, which is the ratio of the area of the part of the sphere corresponding to the entrance aperture of the counter to the total surface of the sphere of equal intensity.

Let $R$ be the radius of the sphere, in the center of which the point source of radiation is located. Then to find the geometric factor it is necessary to find the area $S$ of the part of the sphere cut off by the entrance hole of the tube. For this purpose, denoting by $\varphi$ the angle between the tube axis and the radius of the sphere, let us identify the elementary part $\Delta\varphi$ of the solid angle corresponding to the angle $\varphi$.

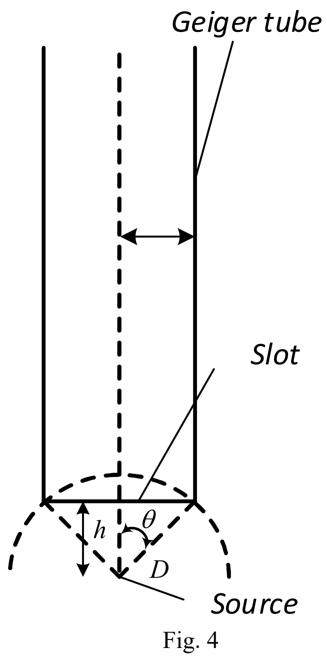


Fig. 4

Let us find the area $\Delta S$ of the spherical ring, which corresponds to the elementary part $\Delta\varphi$ of the solid angle, as the difference of the areas of two circles with radii $p+\Delta p$ and $p$ (Fig. 5):

$$\Delta S = 2\pi p\Delta p.$$

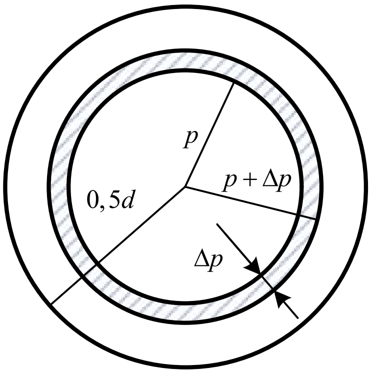


Fig. 5

But $p = R\sin\varphi$, and $\Delta p$ will be replaced by the length of the arc of a circle with radius $R$ and center angle $\Delta\varphi$, i.e. $\Delta p = R\Delta\varphi$.

So, uh.,

$$\Delta S = 2\pi R^2 \sin\varphi\Delta\varphi, \text{ или}$$

$$dS = 2\pi R^2 \sin\varphi d\varphi,$$

i.e. the simplest differential equation is obtained.

Hence

$$S = 2\pi R^2 \int_0^\theta \sin\varphi d\varphi,$$

where $\theta$ is the angle between the axis of the meter tube and the radius of the sphere drawn to the edge of the inlet (see Fig. 4).

So, uh.,

$$S = 2\pi R^2(1-\cos\theta).$$

The latter formula makes it possible to calculate the desired area of the part of the sphere cut out by the counter tube [19].

*Task.* Find the geometric factor $G$ for a Geiger counter provided that the distance $h$ from the radiation source to the inlet aperture is much greater than the diameter of the tube $d$, i.e. $h >> d$.

D e c i s i o n.

$$G{::}= \frac{S}{S_{сферы}} = \frac{2\pi R^2(1-\cos\theta)}{4\pi R^2} = \frac{1}{2}(1-\cos\theta).$$

But

$$\cos\theta = \frac{h}{\sqrt{h^2+r^2}} = \frac{1}{\sqrt{1+(r/h)^2}}, \text{ где } r = d/2.$$

Expression $\frac{1}{\sqrt{1+(r/h)^2}}$ is represented by the Taylor formula in the neighborhood of zero:

$$\frac{1}{\sqrt{1+(r/h)^2}} = 1 - \frac{1r^2}{2h^2}.$$

So the geometric factor for a Geiger counter

$$G = \frac{r^2}{4h^2} = \frac{d^2}{16h^2}.$$

**Conclusions and prospects for further development of this direction.**

The article considers some examples of application of integrals, which can be used in practical classes in higher mathematics, teaching students of chemical specialties.

Examples of problems with physical and chemical content are given. Most often, when studying the course of higher mathematics have to solve problems of a general nature. But for the students of the Training and Research Institute of Chemical Technologies and Engineering the tasks that are directly related to their specialty are of greater interest.

Thus, by considering problems such as those given in this article, we will increase the interest and motivation of future specialists to study this material. Also, when applying integrated training sessions, students form and develop professional competencies that allow them to perform engineering research work on specific technological processes [19–22].

**References (transliterated)**


1. Zvychaini dyferentsialni rivniannia ta yikh zastosuvannia pry rozviazuvanni prykladnykh zadach : navch. posib. dlia studentiv khimichnykh spetsialnostei / O. P. Prishchenko, T. T. Chernohor. – Kharkiv : NTU «KhPI», 2025. – 142 s.
2. PodvIyniy ta potrIyniy Integrali : navch. posIb. / Pershina Yu.I., PrIschenko O.P., Cheremska N.V., Chernogor T.T. – HarkIv : Vidavnitstvo «Drukarnya Madrid», 2022. – 106 s.
3. Diferencial'ni rivnyannya ta ïh zastosuvannya : n.-met. posib. / Prishchenko O.P., CHernogor T.T. – . Kh : NTU «KhPI», 2017. – 88 p.
4. Prishchenko O.P., Chernogor T.T. Analiz prikladiv zastosuvannya diferencial'nih rivnyan' v himichnij ta harchovij tekhnologiï // Visnik NTU «KhPI». – Kharkiv : NTU «KhPI», 2018. – № 40 (1316). – pp. 39 – 45.
5. Prishchenko O.P., Chernogor T.T., Bukhkalo S.I. Deyaki osoblivosti provedennya korelyaciijnogo analizu Informacijni tekhnologiï: nauka, tekhnika, tekhnologiya,

osvita, zdorov'ya: tezi dopovidej XXVII mizhnarodnoї naukovo-praktichnoї konferencії MicroCAD-2019, 15-17 travnya 2019 r.: u 4 ch. CH. II. / za red. prof. Sokola Є.I. – Harkiv: NTU «KhPI». – p.320.
6. Prishchenko O.P., Chernogor T.T. Deyaki osoblivosti provedennya regresijnogo analizu Informacijni tekhnologiї: nauka, tekhnika, tekhnologiya, osvita, zdorov'ya: tezi dopovidej XXVII mizhnarodnoї naukovo-praktichnoї konferencії MicroCAD-2019, 15-17 travnya 2019 r.: u 4 ch. CH. II. / za red. prof. Sokola Є.I. – Kharkiv: NTU «KhPI». – p. 319.
7. Prishchenko O.P., Chernogor T.T. Using of methods of cross-correlation and regressive analysis for determination of functional dependence between sizes // Visnik NTU «HPI» Seriya: Innovacijni doslidzhennya u naukovih robotah studentiv. – Kharkiv : NTU «KhPI», 2019. – №15 (1340). – pp. 36 – 41.
8. Prishchenko O.P., Chernogor T.T. Analysis of opportunities of analytical method of optimization in chemical technology // Visnik NTU «KhPI» Seriya: Innovacijni doslidzhennya u naukovih robotah studentiv. – Harkiv : NTU «KhPI», 2020. – №5 (1359). – pp. 71 – 77.
9. Prishchenko O.P., Chernogor T.T. Vikoristannya tenzoriv pri analizi osoblivostej fizichnih vlastivostej tverdih til // Visnik NTU «HPI» Seriya: Innovacijni doslidzhennya u naukovih robotah studentiv. – Kh : NTU «KhPI», 2020. – №6 (1360). – pp. 42 – 48.
10. Prishchenko O.P., Chernogor T.T. Application of elements of studying the function of one variable when solving chemical problems // Visnik NTU «KhPI» Kh : NTU «KhPI», 2021. – №1 (1361). – pp. 30 – 35.
11. Prischenko O.P., Cheremska N.V., Chernogor T.T. Pobudova matematichnih modeley za dopomogoyu metodIv korelyatsIynogo i regresiynogo analIzu // Visnik NTU «KhPI». Kh : NTU «KhPI», 2021. №62 (1362), pp. 29 – 36.
12. Prischenko O. P., Cheremska N. V. Rekonstruktsiya gausovskih vipadkovih funktsiy za danimi spektru // Visnik NTU «HPI» Seriya: Matematichne modelyuvannya v tehnitsi ta tehnologiyah. Kh : NTU «KhPI», 2021. №1-2 pp. 97 – 103.
13.. Prishchenko O. P., Cheremskaya N. V, Chernogor T. T, Bukhkalo S.I. Innovative methods of teaching the discipline higher mathematics to students studying chemical technology and engineering // VIsnik NTU «HPI» SerIya: InnovatsIynI doslIdzhennya u naukovih robotah studentIv. – HarkIv : NTU «HPI», 2022. – №1(1363). – pp. 30 – 37.
14. Prishchenko O.P., Cheremskaya N.V, Bukhkalo S.I. Examples of information technologies for reconstruction from the data of the spectrum of some classes of random functions // VIsnik NTU «KhPI» SerIya: InnovatsIynI doslIdzhennya u naukovih robotah studentIv. – Kh : NTU «KhPI», 2022. – №1 (1363). – pp. 38 – 43.
15. Prishchenko O. P. Dependence of the maximum rate of nitric oxide oxidtion on the concentration of reactants. InformatsIynI tehnologIYi: nauka, tehnIka, tehnologIya, osvIta, zdorov'ya: tezi dopovIdey XXX mIzhnarodnoYi naukovo-praktichnoYi konferentsIYi MicroCAD-2022, 19-21 zhovtnya 2022 r. / za red. prof. Sokola E.I. – KharkIv: NTU «KhPI». – p. 389.
16. Prishchenko O.P., Chernogor T.T. Investigation of the reaction rate constant plot. InformatsIynI tehnologIYi: nauka, tehnIka, tehnologIya, osvIta, zdorov'ya: tezi dopovIdey HXX mIzhnarodnoYi naukovo-praktichnoYi konferentsIYi MicroCAD-2022, 19-21 zhovtnya 2022 r. / za red. prof. Sokola E.I. – Kh: NTU «KhPI». – p. 390.
17. Hranytsi ta neperervnist funktsii : navch.-metod. posib. / Pershyna Yu.I., Prishchenko O.P., Chernohor T.T. – Kharkiv : NTU «KhPI», 2023. – 148 p.
18. Prishchenko O. P., Chernogor T. T. Sonstruction of statistical models of chemical and technological objects on the basis of a complete factor experiment // Visnyk NTU «KhPI» Seriia: Innovatsiini doslidzhennia u naukovykh robotakh studentiv. – Kharkiv : NTU «KhPI», 2023. – №1 (1365). – pp. 32 – 38.
19. Prishchenko O. P., Chernogor T. T. Application of an active experiment to the construction of statistical models of chemical-technological objects. Informatsiini tekhnolohii: nauka, tekhnika, tekhnolohiia, osvita, zdorovia: tezy dopovidei XXXI mizhnarodnoi naukovo-praktychnoi konferentsii MicroCAD-2023, 17-20 travnia 2023 r. / za red. prof. Sokola Ye.I. – Kharkiv: NTU «KhPI». – p. 511.
20. Prishchenko O. P., Chernogor T. T. Investigation of the degree of decomposition of nitric acid polyhalite based on a complete factor experiment. Informatsiini tekhnolohii: nauka, tekhnika, tekhnolohiia, osvita, zdorovia: tezy dopovidei XXXI mizhnarodnoi naukovo-praktychnoi konferentsii MicroCAD-2023, 17-20 travnia 2023 r. / za red. prof. Sokola Ye.I. – Kharkiv: NTU «KhPI». – p. 512.
21. Bukhkalo S.I. Dejaki modeli procesiv himichnogo spinjuvannja vtorinnogo polietilenu. Visnik NTU «KhPI» Serija: Innovacijni doslidzhennja u naukovih robotah studentiv. – Harkiv : NTU «KhPI», 2017. – №18 (1240). – s. 35 – 45.
22. Bukhkalo S.I. Modeljuvannja procesiv innovacijnih energotehnologij utilizacії polimeriv. Tezi VI Mizhnarodnoї naukovo-praktichnoї konferencії «Innovacijni energotehnologiї». – Odesa: ONAHT, 2017

*Надійшла (received) 24.03.2025*

*Відомості про авторів / Сведения об авторах / About the Authors*

***Пріщенко Ольга Петрівна (Prishchenko Olga Petrivna)*** – старший викладач кафедри вищої математики, Національний технічний університет «Харківський політехнічний інститут», м. Харків, Україна;
ORCID: http://orcid.org/0000-0003-0530-2131;
e-mail: priolga2305@gmail.com

***Черногор Тетяна Тимофіївна (Chernogor Tetyana Timofiyivna)*** – старший викладач кафедри вищої математики, Національний технічний університет «Харківський політехнічний інститут», м. Харків, Україна;
ORCID: http://orcid.org/0000-0002-7823-7628;
e-mail: tatyanachernogor54@gmail.com