– Variations in sample composition: sample heterogeneity can lead to different results with different parts of the sample.

– Conditions of analysis: changes in temperature, air humidity or pressure.

To account for these factors, formulae for calculating Type A and B standard uncertainty, as well as total and expanded uncertainties, were used. For example, for the chromatographic method, the overall uncertainty u_c was calculated as:

$$u_c = \sqrt{u_A^2 + u_B^2}, \quad (2)$$

where u_A is the Type A standard uncertainty, u_B is the Type B standard uncertainty.

Practical application of methods

– The titrimetric method is most suitable for laboratories with limited budgets as it requires minimal equipment costs.

– The chromatographic method is recommended for large production plants where high precision of analysis is important.

– The spectrophotometric method allows rapid and accurate determination of butyric acid content in complex samples.

– Machine learning techniques can be useful for automating the analysis process in industrial settings, but require large amounts of data to train models.

Conclusion. Based on the analysis performed, it can be concluded that the choice of method for the determination of butyric acid content depends on the type of product, required accuracy, equipment availability and budget. Classical methods remain relevant for small laboratories, while modern technologies such as spectroscopy and machine learning offer new opportunities for automation and improved accuracy of analysis.

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EDUCATIONAL AND METHODOLOGICAL COMPLEX ON THE SUBJECT “DIFFERENTIAL GEOMETRY”

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The purpose of this work: to tell about the development of electronic educational and methodological complex on the discipline “Differential Geometry” in English, intended for work with Chinese master students. These teaching materials will be a part of the author’s master thesis.

Material and methods. The main source is the lectures of the scientific supervisor and the textbook published under the stamp of the educational and methodological association for pedagogical education, one of the authors of which is the scientific supervisor [1].

Findings and their discussion. The subject "Differential Geometry" is studied by foreign students of the specialty “Physics and Mathematics Education”. For the successful

work, it is necessary to have electronic educational and methodological complex posted in the distance learning system of VSU https://tfc.vsu.by .

The teaching and methodological complex developed by the author consists of three parts. The first part is a summary of lectures on the section “Theory of Curves”. It includes the topics “Vector function of a scalar argument”, “The concept of a path and a curve’, “Tangent line and normal plane”, “Length of a curve and a natural parameter’, “Osculating plane and binormal”, “Curvature and torsion of a curve”, “Frenet frame” and a number of additional topics, including the fundamental theorem of the theory of curves, the envelope, the evolute and the evolvent. The presentation of theoretical material is accompanied by a large number of high-quality drawings that help to clearly present the material being studied.

The second part of the educational and methodological complex contains examples of solving various problems in the theory of curves.

The third part is intended for practical classes. It contains control questions and as-signments, problems to be solved in practical classes with answers to them, as well as assign-ments for independent solution. Before the practical lesson on each topic, the student must check himself that he knows the answers to all the control questions on the topic being studied.

The fourth part of the educational and methodological complex consists of test questions. These questions will be placed in the distance learning system and tests will be formed from them. Questions of various types have been developed. The most productive are questions on compliance. They allow you to combine 4–5 questions in one question. Here is an example of such a question.

30. *Arrange the following lines*

1) *binormal*, 2) *principal normal*, 3) *tangent*

in accordance with the order of the planes to which they are perpendicular:

normal, *osculating*, *rectifying*.

a) 1, 2, 3;
b) 3, 1, 2;
c) 2, 3, 1;
d) 3, 2, 1;
e) 2, 1, 3.

Also of great interest are questions in which it is necessary to select two conditions under which the conclusion of the theorem takes place. Here is an example of such a question.

38. *Specify two conditions under which the curve at a given point has torsion*:

a) *continuous*; *b*) *of the class* C^1, *regular*;

c) *of the class* C^2, *regular*; *d*) *smooth of the class* C^3;

e) $\vec{c}' \cdot \vec{c}'' \neq 0$; *f*) $\vec{c}' \vec{c}'' \vec{c}''' \neq 0$; *g*) $\vec{c}' \times \vec{c}'' = 0$; h) $k \neq 0$.

The final fifth part of the educational and methodological complex contains examples of tasks for a test or credit.

It is also assumed that the electronic educational and methodological complex will contain auxiliary information. Namely, the curriculum for the discipline, a list of literature and hyperlinks to Internet resources. Of particular interest are videos demonstrating the construction of some curves, animation of the osculating plane and binormal, and a moving frame of the curve.

The developed educational and methodological complex is intended not only for foreign students, because the subject “Differential Geometry” is also taught to Belarusian master's students and in English as well. In this case, master students are going to have the exam. Therefore, the educational and methodological complex will also contain materials for the theoretical exam.

Conclusion. We have developed electronic educational and methodological complex that will form part of the master's thesis and will be very useful to other master's students when studying the subject “Differential Geometry” and working on their theses.

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INTEGRATED SAPR FOR THE JACK SEMI-AUTOMATIC SEWING MACHINE

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The **Jack** semi-automatic sewing machine is a specialised machine for making decorative stitches on shoe tops. It allows you to create complex patterns, ornaments and designs with high accuracy and speed. The machine performs stitches according to a pre-loaded programme, which minimises the impact of human error. **DXF** (Drawing Exchange Format), which supports vector images and precise stitch coordinates, is used to transfer designs.

Material and methods. Bresenham's algorithm for discretisation of curves and their transformation into a sequence of points, Simpson's method for numerical integration for calculation of areas of complex figures are used in this work. Experimental studies to verify the accuracy and correctness of the algorithms on real data. Statistical analysis to compare the results obtained by the system with manual calculations and AutoCAD data. Optimisation of needle trajectories of a semiautomatic sewing machine using algorithms that minimise sewing time and equipment wear.

Results and their discussion. The integrated computer-aided design (CAD) system for the Jack semi-automatic sewing machine is a comprehensive solution that combines all stages from design creation to its realisation in the production process. The main task of the system is to convert graphic data from CAD software such as AutoCAD into a format understandable to the equipment, taking into account all technical constraints and sewing quality requirements.

The process starts by importing a DXF file created in AutoCAD. CAD reads this file, analysing its geometry and structure. Each line or arc in the file has exact vertex coordinates, and layers encode the type of line (e.g. contour or fill). A specialised file parsing algorithm is used to extract this data correctly. This algorithm allows to get the coordinates of line nodes, parameters of layers. The result of this algorithm is visually presented in Figure 1, where the structure of processed data is demonstrated.

Next, the objects are divided into stitches - a key data preparation step for the Jack semi-automatic machine. For straight lines this process is relatively straightforward, but curved objects such as circles or spirals require a special approach. Here, sampling is applied at a specified step size that matches the resolution of the Jack equipment (typically 0.1 mm). This allows smooth curves to be converted into a sequence of points, which will then be used to control the needle movement. The Bresenham algorithm, one of the most efficient methods of converting vector lines into discrete points, is used to perform this task. The algorithm provides high accuracy and minimises errors in the conversion. The implementation of the algorithm is shown in Figure.

```
import ezdxf
def read_dxf(file_path):
doc = ezdxf.readfile(file_path)
msp =  doc.modelspace()
```