

SEEJSD

SOUTH EAST EUROPEAN JOURNAL OF SUSTAINABLE DEVELOPMENT

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Mother Teresa University in Skopje

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Skopje 1000

Republic of North Macedonia

Phone: +389 2 3161 004

E-mail: seejsd@unt.edu.mk

Web: www.seejsd.unt.edu.mk

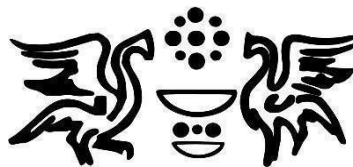
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Editorial Foreword

Prof. Dr. Sani Demiri
Editor in Chief

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Dear Readers, Authors and Collaborators,

As we usher in 2026 at Mother Teresa University in Skopje, the South East European Journal of Sustainable Development (SEEJSD) is proud to present this special issue featuring selected contributions from the 9th International Conference Towards Sustainable Development (TSD 2025).

Building on the success of TSD 2024, which brought together international experts to address energy transitions, artificial intelligence challenges, and European integration in the context of sustainable development, this issue highlights forward-looking research and practical solutions relevant to the Western Balkans and the wider global community.

The contributions in this volume explore key themes including techno-economic sustainability, emerging directions in architecture, cybersecurity in the AI era, and the role of social sciences in evidence-based policymaking. All papers have undergone a rigorous peer-review process conducted by our distinguished editorial board, ensuring high academic quality and strong societal relevance. Collectively, they offer actionable insights aimed at strengthening regional resilience and advancing alignment with the United Nations Sustainable Development Goals (SDGs).

We extend our sincere gratitude to all authors, reviewers, and the university leadership whose dedication and support continue to foster meaningful dialogue on these critical issues. We invite our readers to engage deeply with the research presented in this issue—your insights and feedback play a vital role in shaping future editions and amplifying real-world impact.

Prof. Dr. Sani Demiri, PhD
Editor in Chief

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VISUALIZATION OF ANALYTICAL GEOMETRY PROBLEMS

Elena Karamazova Gelova,

Faculty of Computer Science, Goce Delcev University, Stip, North Macedonia,

elena.gelova@ugd.edu.mk

Mirjana Kocaleva Vitanova

Faculty of Computer Science, Goce Delcev University, Stip, North Macedonia,

Aleksandar Velinov

Faculty of Computer Science, Goce Delcev University, Stip, North Macedonia,

Biljana Zlatanovska

Faculty of Computer Science, Goce Delcev University, Stip, North Macedonia,

Zoran Zlatev

Faculty of Computer Science, Goce Delcev University, Stip, North Macedonia,

ABSTRACT

Nowadays there is a wide range of software for visual solving of mathematical problems, but most of the textbooks intended for learning contain only manual solutions of the problems. In this paper, we decided to use GeoGebra software to solve problems from analytical geometry where it is very important to see visually the process of obtaining a solution and what the final solution looks like. The visual solutions are shown in the paper, as well as the steps for obtaining them. The GeoGebra is also used for visualization.

Keywords: *visualization, analytical geometry, GeoGebra*

Introduction

Nowadays, the technology is used in a wide variety of fields. Computers and internet are used by lots of people. Without them we cannot imagine the new modern way of living. There are different reasons for using it such as professional working, access to information, teaching, learning, communication, collaboration etc. Teaching is often helped with software [1], [3], Artificial Intelligence (AI) [7], [8], Moodle as a platform for e-learning [9], [10], [11], etc. The Information and Communication Technology (ICT) tools are very important in the learning process [2], [4]. The purpose of this paper is to demonstrate the use of GeoGebra software for learning the topic Analytical Geometry with visual representation of tasks and their solution. Analytical Geometry problems are studied by students at primary school, secondary school and university levels, especially those students who have chosen to study technical sciences.

Considering the problems of students in solving such problems, such as difficulties in manually and graphically representing the data given in the problem and the solution, as well as uncertainty about whether the solution is correct, we decided to consider problems from analytical geometry by visualizing the steps to obtain a solution and the final solution. A similar goal has been achieved in the papers [1] and [3] where topic function and plane equation are explored with visualization using GeoGebra software, in [6] where visualization of discrete random variables is made and in [5] where the importance of visualization in Mathematics is reviewed.

Purpose of Study

The main reasons for writing this paper are the shortcomings in textbooks on analytical geometry, which lack a visual representation of the problems and their solutions. Another motivation for writing is the insufficient knowledge of students on this topic.

Research Methods


The problem with the tasks from analytical geometry will always be present. It will appear in secondary school or faculty. In the schools and the faculties around the world, the problem of solving tasks from analytical geometry became especially popular because the standard books which are used in the teaching process do not contain geometric representation of the problems. For the purposes of this paper, tasks from analytical geometry were solved with software GeoGebra to provide material for studying this topic with visualization of the steps for solving tasks and visualization of tasks and their solutions. Then, a comparison is made of literature with and without visualization on this topic, after which conclusions are drawn about the advantages and disadvantages of each type of learning material. Finally, a conclusion is drawn about how it is better to study this topic.

Findings and Results

In this paper problems with ellipse, vectors, circle and line will be considered. For all of them, we have a visual representation with figures of some steps in solving and figure of the final solution of the problems. The idea is realized with the mathematical software GeoGebra.

First, we begin with the task for ellipse.

Exercise 1. Write the equation of the ellipse if its two vertices are the points $A_1(-13, 0)$ and $A_2(13, 0)$, and the foci are $F_1(-5, 0)$ and $F_2(5, 0)$.

Solution. If the points are entered into GeoGebra and the tool  is used the ellipse and its equation are obtained in GeoGebra (Figure 1):

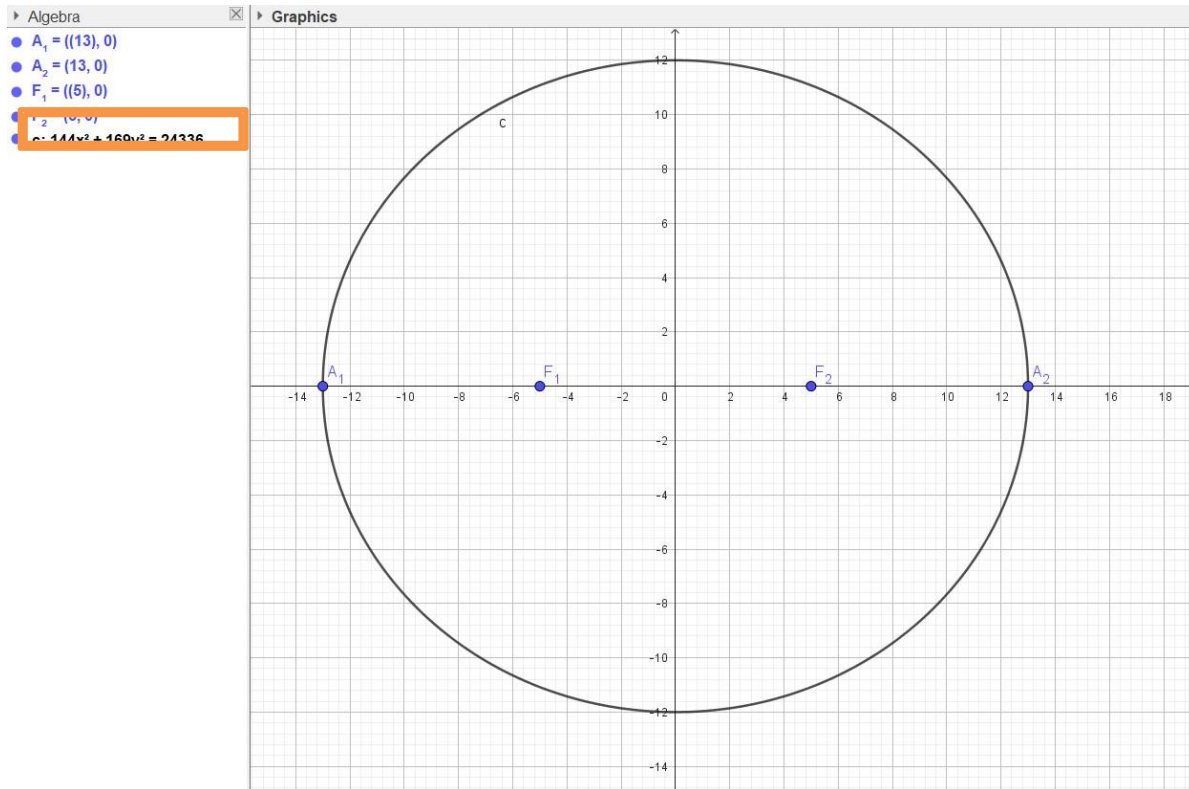


Figure 1. The ellipse and its equation

The solution is precisely correct and obtained in just a few seconds.

Exercise 2. Determine the position of points $A(6,-3)$, $B(-2,5)$, $S(3,-6)$ and $D(-4,2\sqrt{6})$ in relation to the ellipse $\frac{x^2}{48} + \frac{y^2}{36} = 1$.

Solution. The points and the ellipse are entered into GeoGebra.

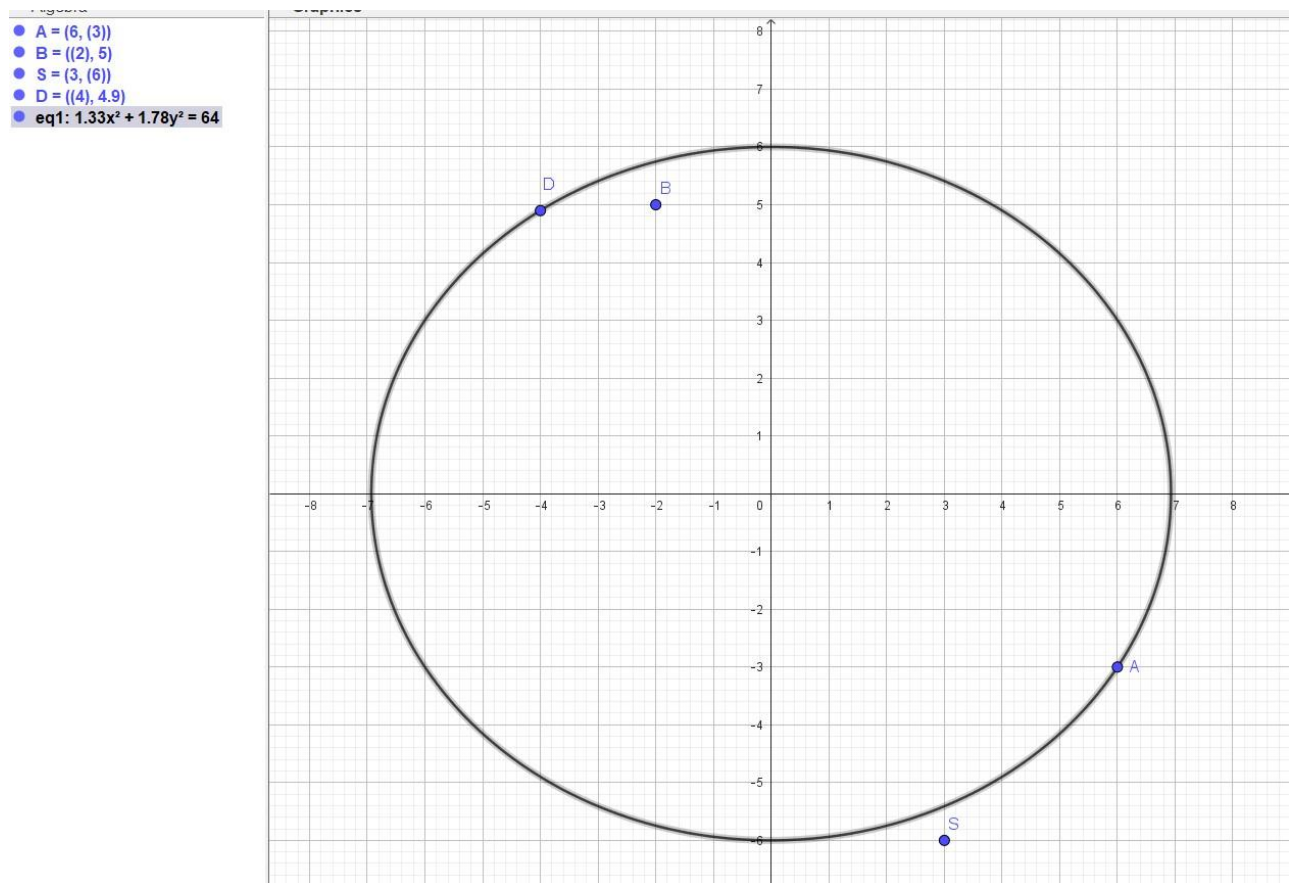


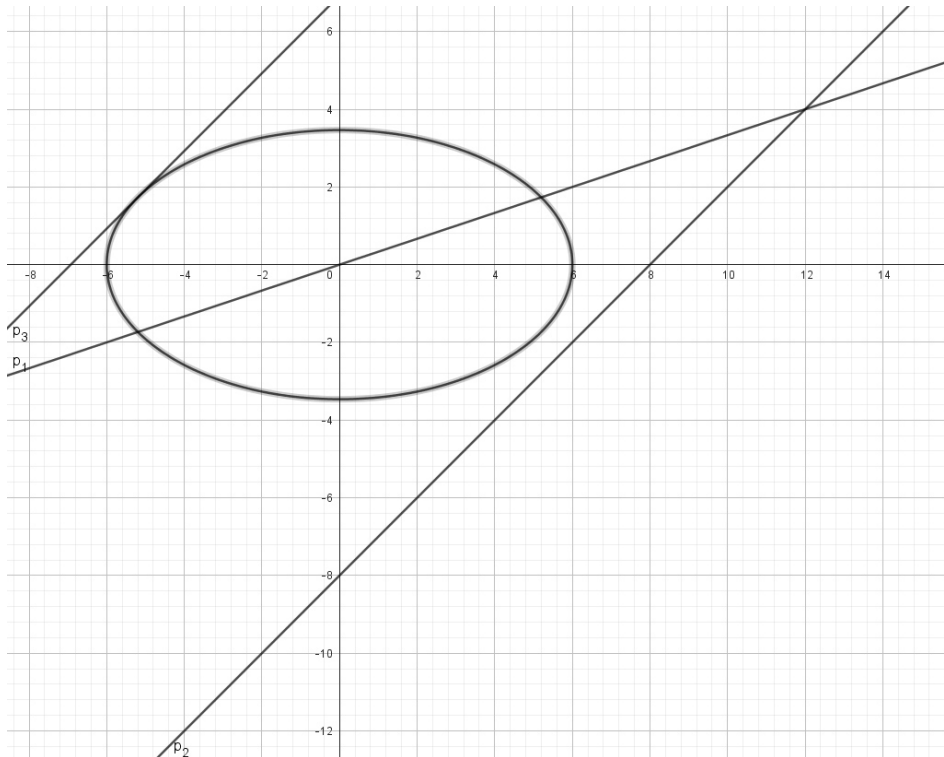
Figure 2. The ellipse and the point of this task

As can be seen in Figure 2, the points A and D lie on the ellipse, point S is outside the ellipse and point B is inside the ellipse. The result is also obtained in just a few seconds.

Exercise 3. Determine the position of the ellipse $x^2 + 3y^2 = 36$ and line

- a) $p_1: x - 3y = 0$; b) $p_2: y = x - 8$ c) $p_3: y = x + 4\sqrt{3}$.

Solution. The ellipse and the line are entered into GeoGebra (Figure 3).



a) As can be seen in Figure 3 the line p_1 intersects the ellipse. The intersection points of the line and the ellipse will be found with the tool Intersect:



After using the tool in Algebra window can see the points of intersect A(5.2, 1.73) and B(-5.2, -1.73)

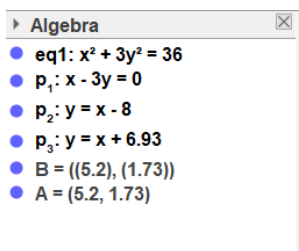
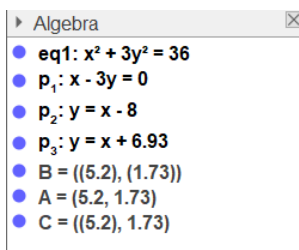


Figure 3. The ellipse and line of this task




b) the line p_2 and the ellipse have no common points

c) The line p_3 and the ellipse have one point in common, i.e. the line touches the ellipse. The point in which the line touches the ellipse can be found with tool Intersect in GeoGebra. The point is C((-5.2), 1.73).

Exercise 4. In points A(8,3) and B(6,-4) from ellipse $x^2 + 4y^2 = 100$ draw tangents.

- Algebra
- A = (8, 3)
 - B = (6, -4)
 - eq1: $x^2 + 4y^2 = 100$
 - f: $2x + 3y = 25$
 - g: $3x - 8y = 50$
 - C = (14, 1)
- $x^2+4y^2=100$.

Solution. The points A and B are entered into GeoGebra and then the ellipse. With the tool  in GeoGebra the equations of the tangents at the points A and B are obtained which can be seen in the algebra window as f and g. In Figure 4, it can be seen those tangents on the ellipse

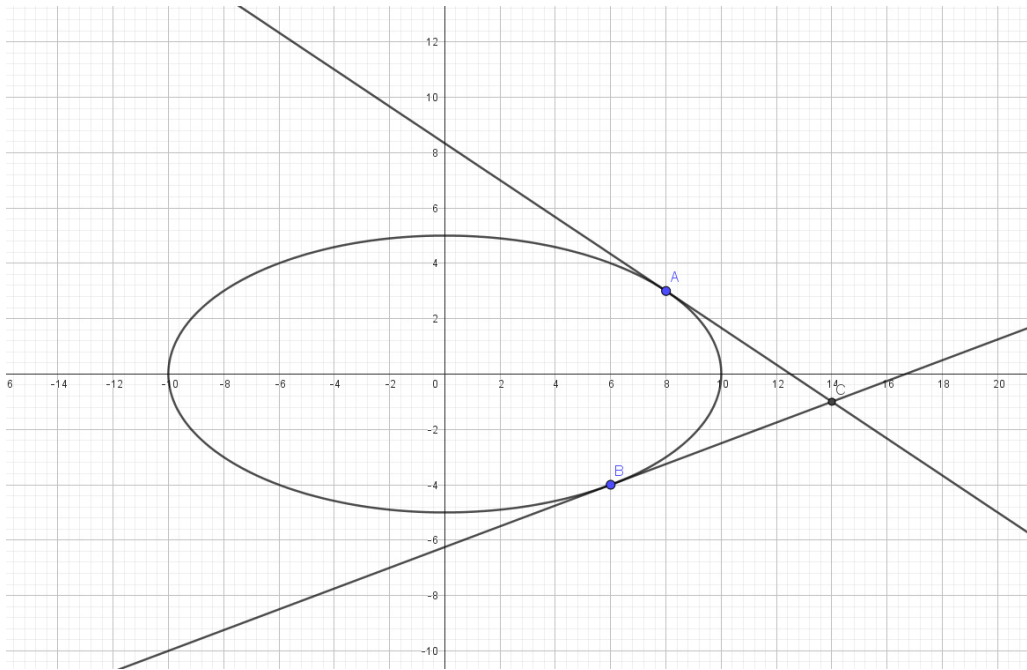
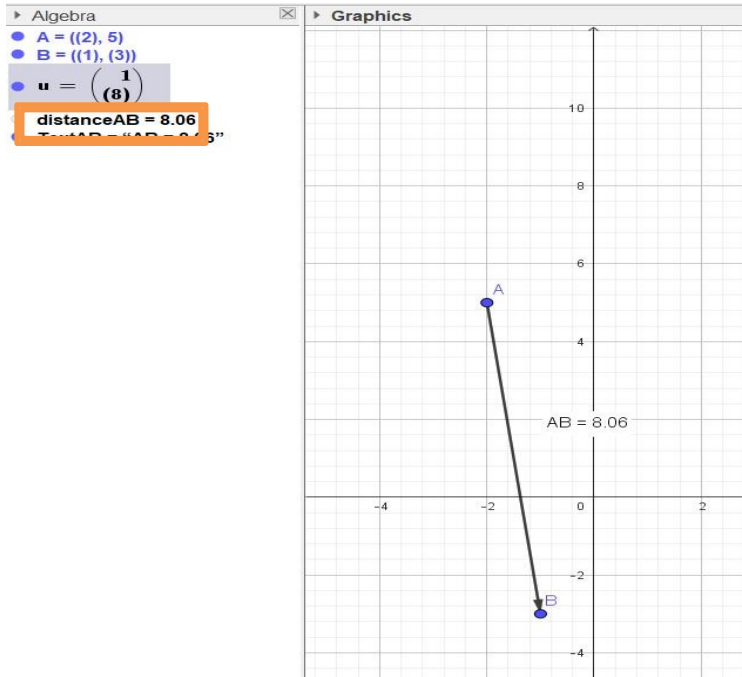


Figure 4. Tangents in points A(8,3) and B(6,-4) on ellipse $x^2+4y^2=100$.



Exercise 5. Determine the length of the vector \vec{AB} if $A(-2,5)$ and $B(-1,-3)$.




Solution. Enter the two points into GeoGebra and use the tools: first  and then  for getting vectors and their lengths. The solution was obtained in a very short time and a great advantage is that it is also presented visually (Figure 5).

Figure 5. The length of vector \vec{AB} with start point $A(-2,5)$ and end point $B(-1,-3)$.

Exercise 6. Determine the distance from point $M(-1,1)$ to a line $p: 2x + y - 2 = 0$ using GeoGebra.

Solution. Enter the point M and line p into GeoGebra and use the  tool to determine the distance from M to p . In Figure 6, it can be seen that the distance is $d=1.34$.

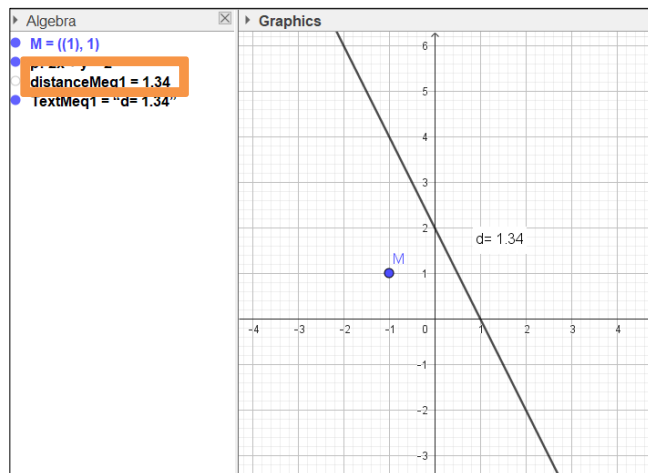



Figure 6. The distance from M to p

Exercise 7. Write the equation of a circle that passes through the points $A(-2,4)$, $B(5,-3)$ and $C(7,1)$.

Solution. Enter the points $A(-2,4)$, $B(5,-3)$ and $C(7,1)$ into GeoGebra and then use the tool  circle through 3 points. In Figure 7, it can be seen the equation of the circle.

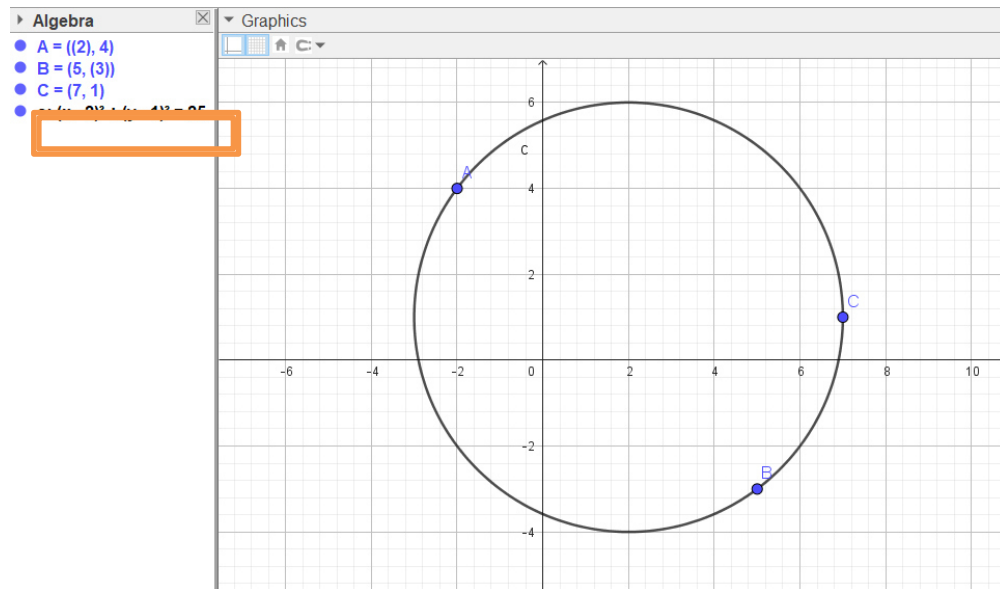


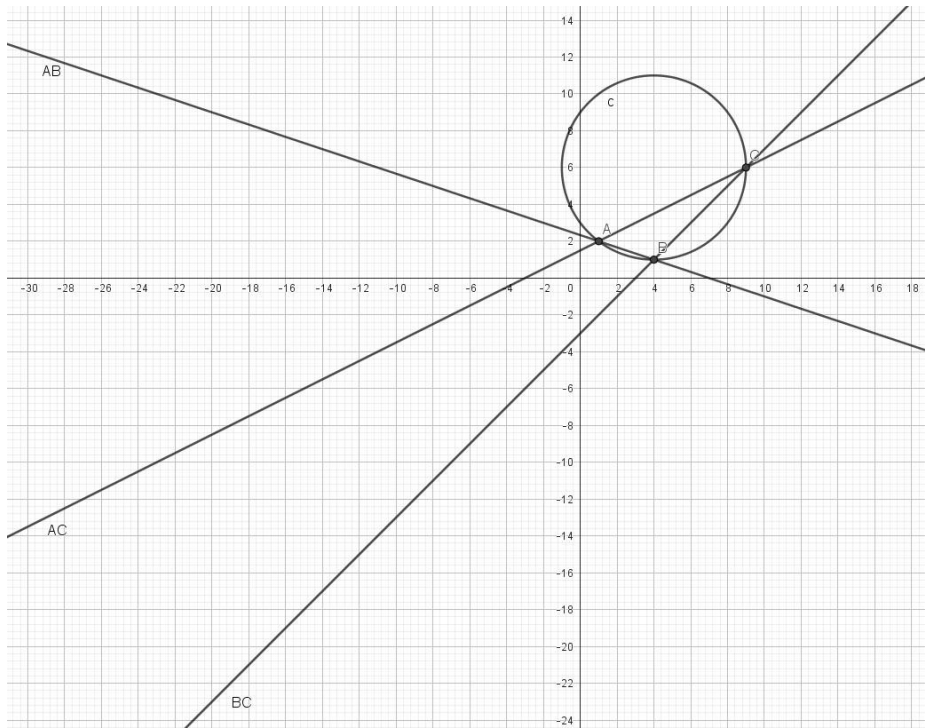


Figure 7. The equation of a circle through point $A(-2,4)$, $B(5,-3)$ and $C(7,1)$

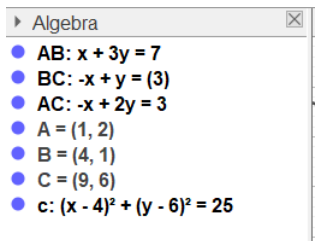
Exercise 8. Write the equation of the circle circumscribed around a triangle, whose equations are the sides $AB: 3y + x - 7 = 0$; $BC: y - x + 3 = 0$ and $AC: 2y - x - 3 = 0$.

Solution. Enter the line $AB: 3y + x - 7 = 0$; $BC: y - x + 3 = 0$ and $AC: 2y - x - 3 = 0$ into GeoGebra and then use the tool Intersect:  to get the points of the triangle. Then with the tool  circle through 3 points is obtained in the geometry window of GeoGebra and in algebra window we can see the equation of the circle which is required in this exercise.



Equation of circle is

$$(x - 4)^2 + (y - 6)^2 = 25.$$





The solution was obtained with GeoGebra, presented visually, and obtained in a very short time.


Figure 8. The line AB , BC , AC and circle $(x - 4)^2 + (y - 6)^2 = 25$.

Exercise 9. The line $p: 3x + y = 1$ intersects the circle $x^2 + y^2 - 2x - 6y + 5 = 0$.

- a) Write the equations of the tangents at the points of intersection
- b) Determine the area of the triangle bounded by the given line and the two tangents.

Solution. Enter line p and circle $x^2 + y^2 - 2x - 6y + 5 = 0$ into GeoGebra and then use the tool

Intersect:  to get the intersect points of line and the circle A and B . Then with tool  in GeoGebra the equations of the tangents at the intersect points are obtained which can be seen in the algebra window as t_1 and t_2 . Intersect point of t_1 and t_2 is obtained with tool Intersect. The

triangle ABC is obtained with the Polygon tool  in GeoGebra. Finally, the area of the triangle



ABC bounded by the t_1 , t_2 and p is calculated with the tool Area in GeoGebra. The area is 2.5, which can be seen in Figure 9.

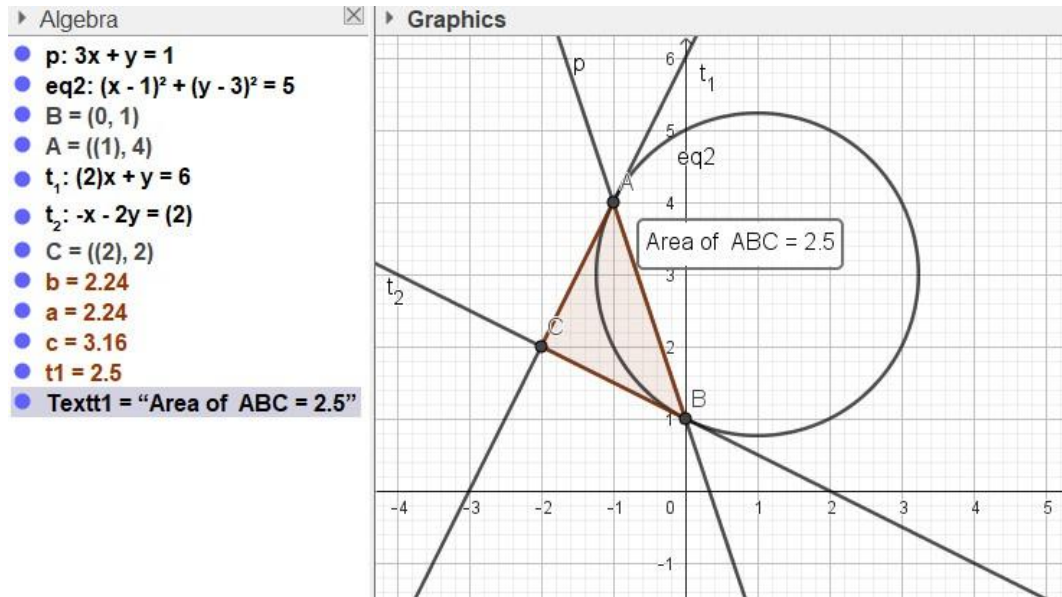


Figure 9. Area of the triangle ABC bounded by t_1 , t_2 and p

This material presented above is much more interesting for students to use than the material in the classical books without visualization of tasks provided in the curriculum of the subject Analytical Geometry. With this material, the learning is easier and the motivation is greater. With standard learning with books sometimes the learning process can be difficult, that is why we need to use some software tools such as GeoGebra in order to improve the studying.

Conclusions and Recommendations

Visualization plays an important role in education, especially in the study of mathematical subjects. By visualizing the steps for solving the problems, we achieve a much more interesting, understandable and attractive study of problems from analytical geometry. Using educational software like GeoGebra, for exercises of analytical geometry, brings us several advantages such as obtaining a solution in a very short time, increasing the desire and interest in learning and increasing the motivation for learning. Some disadvantages of using only books for learning are: boring material, difficult material to learn, material that does not encourage students to learn. The better way to study the topic Analytical Geometry is to use a book supplemented with an education platform for visual representation of analytical problems.

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