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# THE SHAPE AND POSITION OF CURVES OF THE SECOND ORDER

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**ABSTRACT**
*This article discusses the forms and positions of second-order curves on the plane and in space, which are used to define these curves and to determine the position of planes of intersecting second-order surfaces by a given conic section.*
**KEYWORDS**: *applied geometry, engineering graphics, graphic disciplines, second-order curves, ellipse, hyperbola, parabola, circle, parameters, positions, shapes, parametric power, center.*

## 1. INTRODUCTION

For the first time, second-order curves were studied by Menechem, a student of Eudoxus [1-2]. His work was as follows: if you take two intersecting lines and rotate them around the bisector of the angle formed by them, you get a conical surface. If you intersect this surface with a plane, then various geometric shapes are obtained in the section, namely, an ellipse, a circle, a parabola, a hyperbola, and several degenerate shapes.

However, this scientific knowledge found application only in the XVII century, when it became known that the planets move along elliptical paths, and the cannon shell flies along a parabolic path. Even later, it became known that if you give a body the first cosmic speed, it will move in a circle around the Earth, with an increase in this speed – on an ellipse, when reaching the second cosmic speed – on a parabola, and at a speed greater than the second cosmic – on a hyperbola.

**Pascal's theorem:** the points of intersection of opposite sides of a hexagon inscribed in a second-order curve lie on the same straight line.

**Brianchon's theorem:** diagonals passing through opposite vertices of a hexagon described near a second-order curve intersect at a single point.

## 2. MATERIALS AND METHODS

As you know, the space is filled with a set of geometric shapes to select certain shapes from them requires some additional conditions. For example, determining the position and shape parameters of geometric shapes that meet pre-defined conditions. The formation and construction of second-order curves are often found in the educational process for constructing a line of intersection of second-order curved surfaces with a plane and among themselves.

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Therefore, the question of determining the parameters of the position and shape of second-order curves has a special place for teaching graphic disciplines [3-8].

Parameters that determine the positions of second-order curves are called second-order curve position parameters. Parameters that determine the shape of second-order curves are called shape parameters of these curves.

This article considers one of the ways to determine the parameters of the position and shape of curves of the second-order line, both on the plane and in space.

## 3. RESULTS AND DISCUSSION

### *1. Parameters of the shape and position of the circle.*

As you know, the shape of an arbitrary circle is determined by its radius R, which is a parameter of the shape of the circle. Therefore, each defined value of R corresponds to a certain shape of a circle on the plane and in space. Therefore, the radius of circles on the plane and in space is one parametric set whose cardinality is ∞.

Parameters the position of an arbitrary circle on the plane is determined by setting the position of its center, which is determined by two parameters (Fig. 1). Therefore, the number of parameters of the position of circles on the plane will be equal to two, the power of this set is equal to-∞. Therefore, an arbitrary circle on the plane can be defined by three parameters: one - the shape parameter (R), and two - the position parameters (center). The set of circles on the plane is a three-parameter set whose cardinality is written ∞.

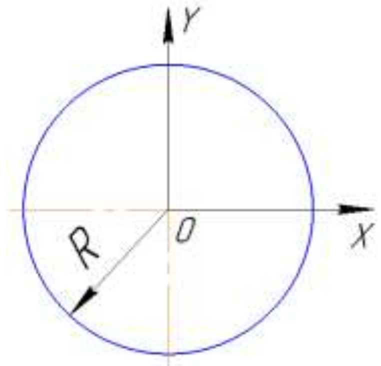


**Fig. 1. The form of a circle.**

Parameters the position of a circle in space is determined by setting the position of its plane, which in space depends on three parameters (Fig. 2). the Power of the set of planes in space is equal to - ∞. Therefore, an arbitrary circle in space can be defined by six parameters, one shape parameter, and five position parameters. The set of circles in the space of six is a parametric set whose cardinality is ∞.

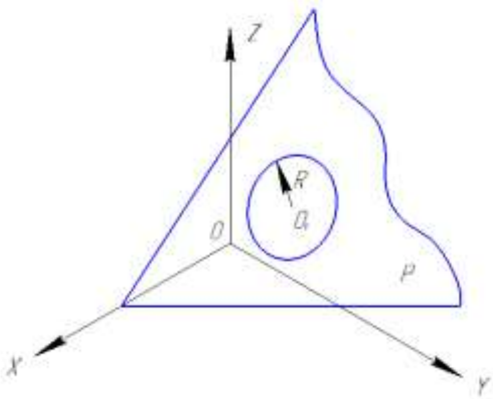


**Fig. 2. a circle Intersecting with the surface along a given conic section.**

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### *2. Parameters of the shape and position of the parabola.*

Parameters of the parabola shape on the plane and in space are determined by the focal parameter. Hence, the parameter of the shape of a parabola on the plane and in space is a one-parameter set whose cardinality is ∞.

Parameters the position of an arbitrary parabola on the plane can be determined by setting its vertex (or focus) and the direction of the parabola axis (Fig. 3). Setting the parabola vertex (point) on the plane is determined by two parameters, setting the direction of the parabola axis determines another parameter. Therefore, the number of parameters for the position of an arbitrary parabola on the plane is three. A set of parabolas on the plane of four is a parametric set whose cardinality is ∞ (one is a parameter of the form. Three-position parameters).

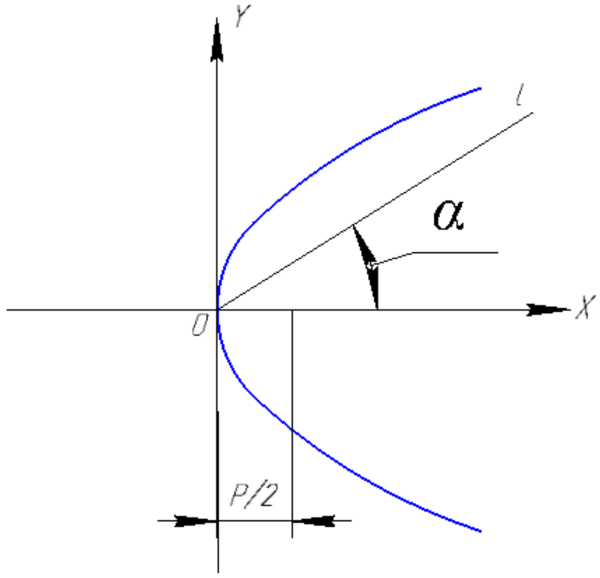


**Fig. 3. Parabola on the plane.**

Parameters the position of an arbitrary parabola in space is determined by setting the position of its plane (Fig. 4), which depends on three parameters the power of this set is equal to-∞. Therefore, the position and shape of an arbitrary parabola in space can be determined by seven parameters - ∞ of these, one is the shape parameter, and six are the position parameters.

The sum of all parabolas in space is a seven-parameter set whose cardinality is written ∞.

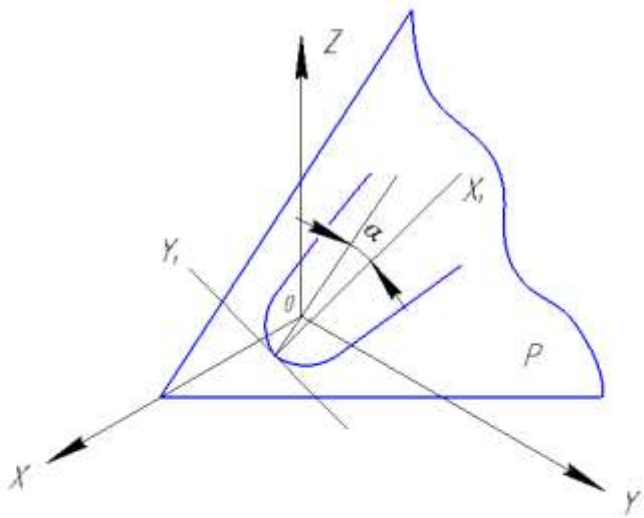


**Fig. 4. Parabola in space.**

### *3. Parameters of the shape and position of the ellipse.*

It is known that of the second-order curves, the ellipse and hyperbola belong to the group of Central curves. They have a center (point) and major axes that define the shapes of these curves. Therefore, the definition of the parameters of the shape and position of the ellipse and hyperbola will be considered similarly.

The shape of an ellipse and hyperbola on the plane and in space is determined by setting their main axes, which are equal to 2A and 2B (Fig. 5). Therefore, the values of the axes of these second-order curves are parameters of the shape of the curves.

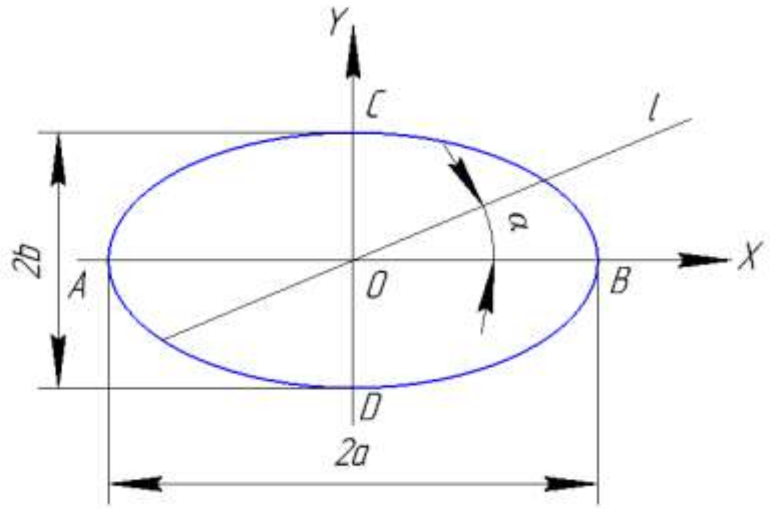


**Fig. 5. Ellipse**

Therefore, the number of parameters defining the shape of an ellipse or hyperbola is equal to two. the power of this set is equal to - ∞.

Parameters the position of an ellipse or hyperbola on a plane can be determined by setting its center (point) and the direction of one of the axes (straight line). Since the second axis is always perpendicular to the first.

Thus, the number of parameters that determine the position of an ellipse or hyperbola on the plane is three. A set of ellipses or hyperballs on a plane, a five-parameter set (two-shape parameters, three-position parameters on the plane), whose power is ∞.

Parameters the position of an ellipse in space is determined by setting the position of their planes (Fig. 6), which depends on three parameters the power of this set is equal to - ∞. Since in the plane of an ellipse or hyperball is defined by five parameters ∞, therefore, the set of ellipses or hyperballs in the space of eight is a parametric set (two of them are shape parameters, six are position parameters), whose power will be equal to ∞.

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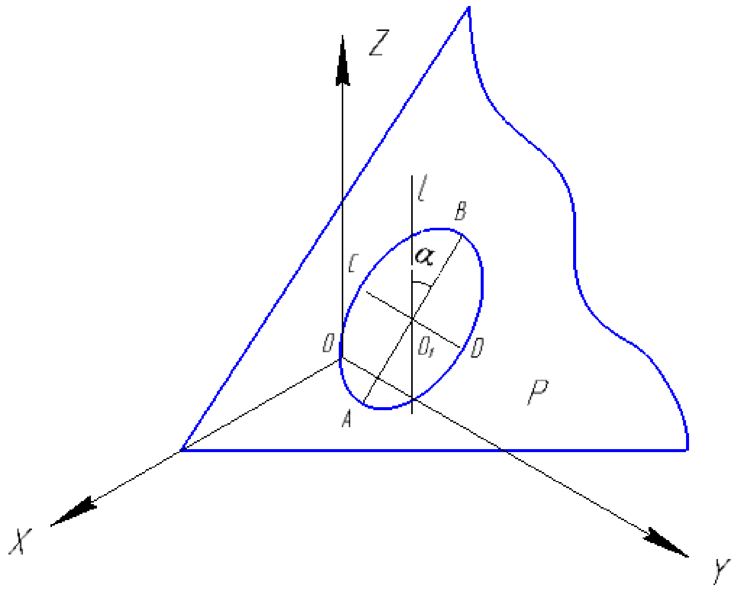


**Fig. 6. Ellipse in space**

The above information for determining the number of parameters for the shape and position of second-order curves, both on the plane and in space, can be determined from table 1.

**Table. 1.**

| Types of second-order curves | Shape parameter | The position parameter | | |
|---|---|---|---|---|
| | | On the plane | On the space | Итог |
| Circle | 1 (R) | 2 | 3 | 6 |
| Parabola | 1 (p) | 3 | 3 | 7 |
| Ellipse | 2 (2a,2в) | 3 | 3 | 8 |
| Hyperbole | 2 (2a,2в) | 3 | 3 | 8 |

## 4. CONCLUSION

The above considerations can be used to define second-order curves and to determine the position of planes that intersect second-order surfaces along a given conic section.

It should be noted that by studying the ways of forming and setting some other higher-order curves, you can determine the number of shape parameters and the position of these curves.

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