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USE OF TYPICAL 3D PRIMITIVE BODIES IN AUTOCAD PROGRAM FOR SOLVING POSITIONAL PROBLEMS OF DESCRIPTIVE GEOMETRY

Abstract. Teaching graphic disciplines to students of technical specialties is the foundation of engineering education. Analysis of academic performance in "Descriptive Geometry" and "Engineering Graphics" courses has shown that the main reason for the decline in results in recent years is the lack of basic knowledge obtained in secondary school. In order to improve the effectiveness of teaching and optimize the learning process, it is necessary to introduce new methods that develop spatial thinking and professional skills. Knowledge of geometric primitives and methods of sectioning shapes is the basis for working in AutoCAD. Effective use of these tools allows you to create complex design solutions and greatly simplify the work in design.

It should be noted that solving geometric problems is done in parallel on both complex drawings and visualizations using the same principles.

This paper shows the use of computer visualization to study sections of three-dimensional bodies (cone, sphere, cylinder) by plane with the help of AutoCAD program. AutoCAD, being a powerful 2D and 3D design tool, provides a wide range of geometric primitives that are the basis for creating complex drawings and models. One of the key aspects of working with these primitives is the ability to create cross sections of shapes, which allows you to visualize the internal structure of objects and analyze their properties. This approach helps to better prepare future engineers to solve practical problems. The simplicity of creating a computer model contributes to the conscious formation of spatial thinking and development of volumetric imagination, as well as to the acquisition of skills in analyzing drawings and geometric constructions. Importantly, AutoCAD also offers the ability to create layered sections, which can greatly enhance teaching and learning in a variety of formats, including lectures, hands-on labs, and distance learning. This software allows instructors to create and share detailed visual representations of concepts, fostering deeper understanding and engagement.

Keywords: descriptive geometry, engineering and computer graphics, modeling, primitive bodies, AutoCAD, positional problems.

Introduction. Descriptive geometry is a graphic discipline that studies methods of depicting three-dimensional objects on the plane, helping to visualize objects and their relationships in space. It is widely used in various fields, making it an important tool for professionals [1-3].

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Descriptive geometry includes a set of geometric techniques that allow a three-dimensional space to be represented in the plane.Thus, it is possible to solve spatial problems in 2D in a way that guarantees the reversibility of the process.Essentially, descriptive geometry is a language that allows us to communicate about shape and space. It is the basis for many professions related to engineering, construction, design and mechanical engineering. Without the knowledge of descriptive geometry, it would be very difficult to create complex objects and bring our ideas to life [1-5].

This language that is descriptive geometry has its own alphabet and grammar. The alphabet is points, lines, planes, the basic elements from which everything else is built. The grammar is the system of rules that define how these elements are projected onto a plane, how they interact with each other in a projection, and how we can extract information about a real three-dimensional object from these projections [1-3].

It underpins many engineering disciplines, architecture and design. Thus, descriptive geometry is an indispensable tool in a wide variety of fields, providing accuracy, clarity and efficiency in design and development [4,5].

Literature Review. The basic principles of engineering graphics have not changed much since the age of Monge [1,2]. However, the last two hundred years have seen an evolution in methods and tools, as well as in standards and conventions, marked by a shift from drawing aids such as the drawing wheel and the scribe to computer-aided design systems [3-9].

CAD systems provide a number of tools that allow positioning and identification of objects without the need to create complex geometric constructions [2-7]. To solve problems in CAD, a three-dimensional model is created and the appropriate commands are applied to it [7]. This provides significant advantages over traditional manual drawing methods [3-9].

In particular, CAD allows transforming the form represented in the computer projective space into a digitized coordinate form by means of transformations providing parallel projections of perspective views [3-9].

Analysis of works [5,7], the study of academic performance in the disciplines "Descriptive Geometry" and "Engineering Graphics" has revealed that the deterioration of indicators in recent years is largely due to insufficient training received at secondary school. In order to improve the effectiveness of training and optimize the learning process, it is important to introduce new techniques that promote the development of spatial thinking and professional skills.

It should be noted that to date, little attention has been paid to the use of 3D modeling in AutoCAD to solve positional problems in descriptive geometry. **The purpose of this paper** is to use graphical modeling using 3D primitive objects in the AutoCAD environment, to analyze and solve problems related to the dissection of three-dimensional bodies by a plane.

Research methodology and results. Most drawings are two-dimensional projections of three-dimensional objects, which is the standard approach for engineers and architects. However, this method is limited due to the difficulty of analyzing such projections. In contrast, the AutoCAD software package has powerful capabilities for creating three-dimensional models and designs [2,4-7]. The AutoCAD graphics package has powerful tools for modeling structures and creating objects in three dimensions. Designing in three-dimensional space allows you not only to reproduce the shape of an object in detail and show it from different points of view, but also to apply coloring, tinting, and even animation to the created objects.

AutoCAD allows you to create three types of three-dimensional objects: wireframe, polygonal (surface), and solid. Each type has its own technique for creating and editing.

Solid modeling is the easiest type of 3D modeling to use. AutoCAD's modeling tools allow you to create 3D objects based on basic spatial shapes (parallelepipeds, cones, cylinders, etc.), as well as by extruding (squeezing) and rotating 2D objects around an axis. Further modification occurs by combining, subtracting, and intersecting the created spatial forms, as well as by editing the edges (conjugation, chamfering, etc.). AutoCAD also provides tools for making cuts and sections of bodies.

The 3D modeling workspace is recommended for working in 3D. You can switch from the current workspace to another workspace with its own set of tools, palettes, and ribbon panels by selecting from the drop-down list in the WSCURRENT toolbar.

You can create 3D solid objects from basic primitives using commands: Box, Cylinder, Cone, Sphere, Pyramid, Wedge, and Torus (Fig. 1).

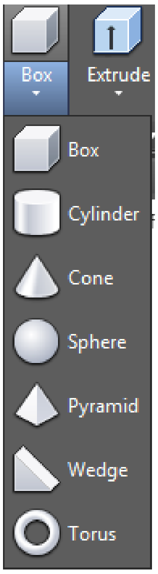
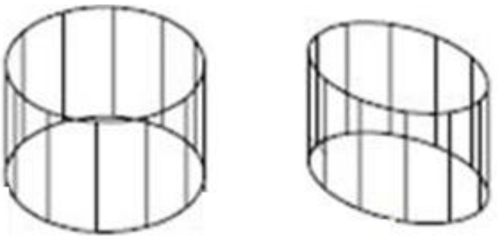


Figure 1 - 3D solid objects AutoCAD

The Cylinder command builds a straight circular and elliptical cylinder (Fig. 2). When selecting, we specify the position of the center, the diameter of the base, and the height of the cylinder.



a) b)

Figure 2 - Straight circular cylinder (a) and elliptical cylinder (b)

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The Cone command builds a straight cone with cylindrical (Fig. 3,a) and elliptical bases (Fig.3,b). When selecting, specify the position of the center, the diameter of the base, and the height of the cone.

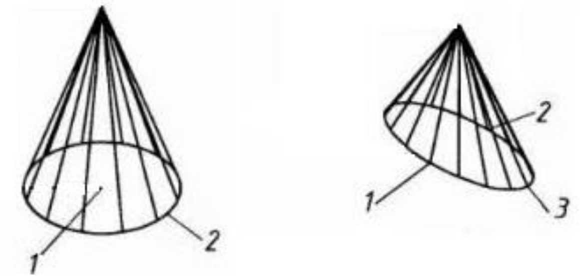


Figure 3 - Rectangular cone with cylindrical (a) and elliptical bases (b)

The Pyramid command builds a regular pyramid by its center and the value of the radius (diameter of the circle described (inscribed) around the polygon of the base) (Fig. 4).

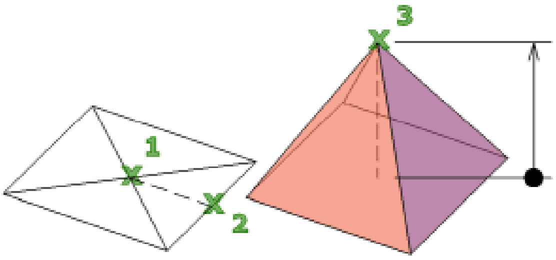


Figure 4 - Building a pyramid

For example, the Figure 5 shows the problem of descriptive geometry - section of a straight cone with a plane as a three-dimensional figure and proeuctions on the basic planes

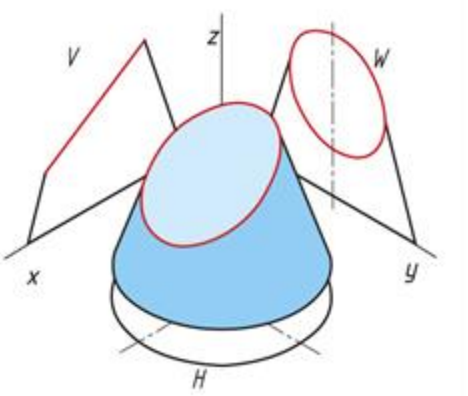
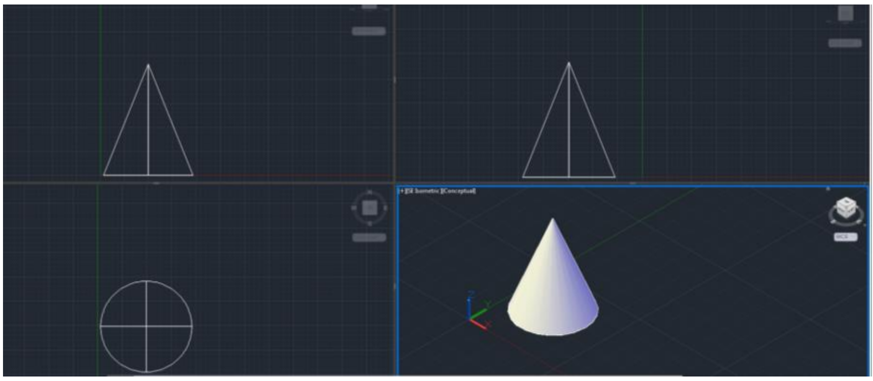


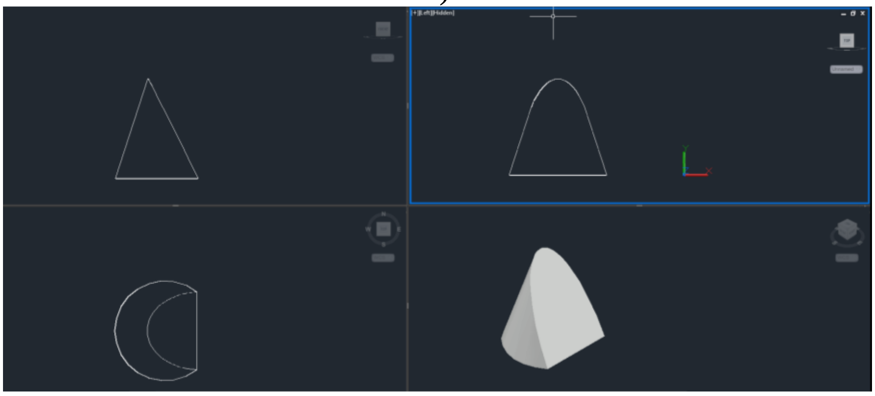
Figure 5 - Building a pyramid

The graphics area in the model space has been divided into several separate rectangular areas - so-called viewports, which display our model in different views (Fig. 6-8). For visualization of three-dimensional shapes (cone, prism), we used the Slice command, which allows us to define a secant plane using three points. The results of modeling are shown in Fig. 6-8.

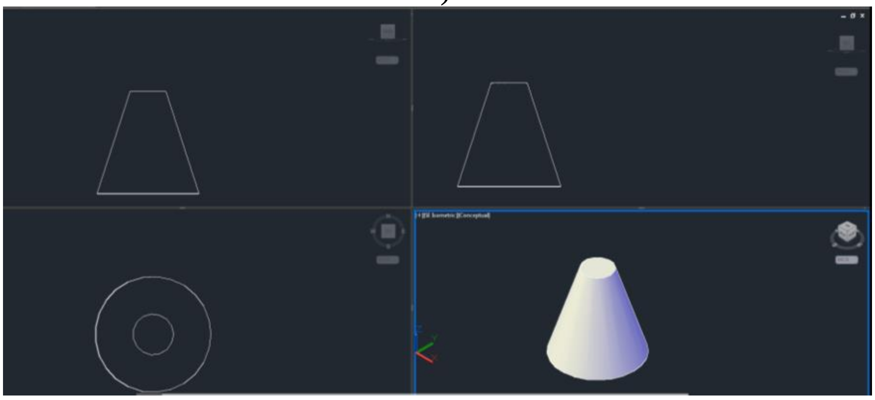
As it follows from Fig.6-8, the construction of primitives does not cause special difficulties. An important point when using basic elements is the ability to build cross-sections of objects, which makes it possible to see their internal structure and study the characteristics of figures in cross-sections. This method effectively prepares future specialists to solve real engineering problems.



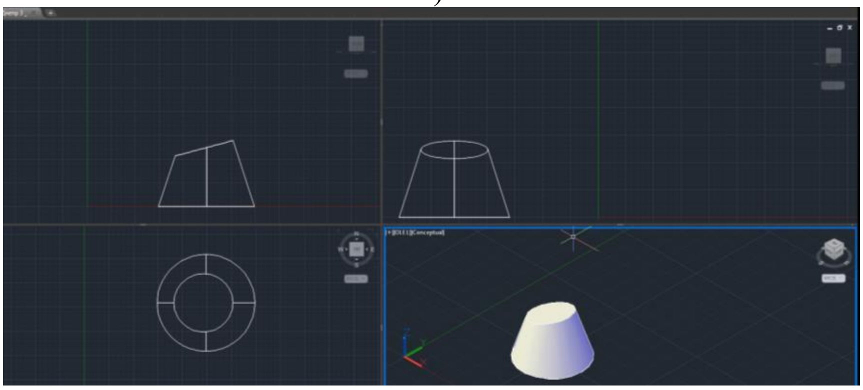
a)



b)



c)



d)

Figure 6 - 3D models and projections of a cone on principal planes truncated by a plane at different angles to the base

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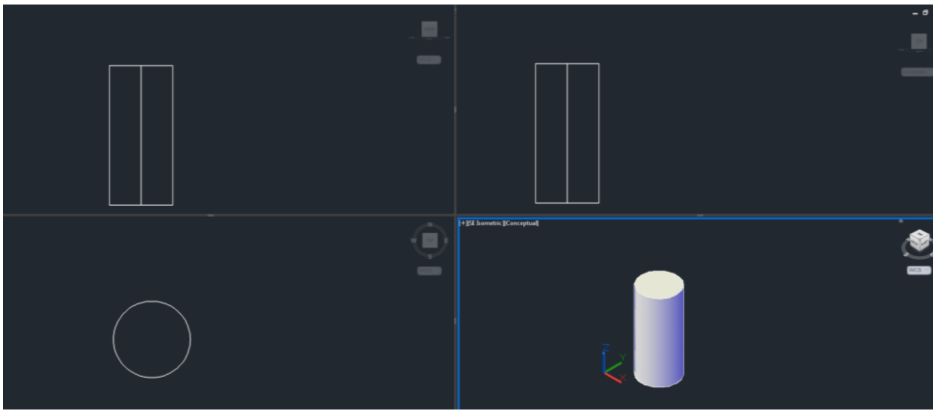
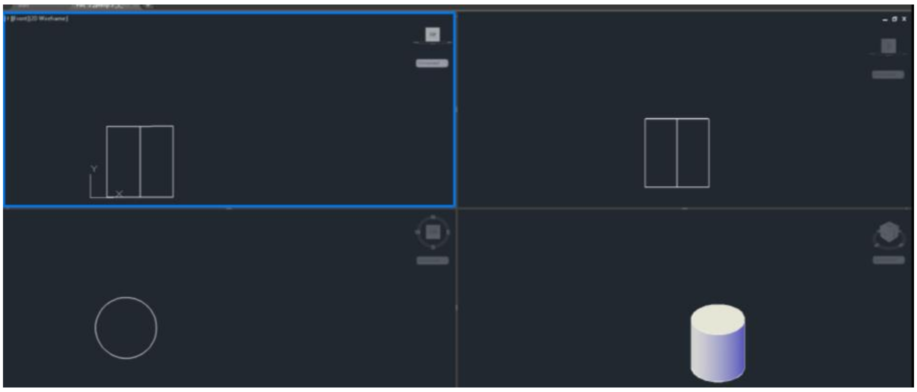


a)



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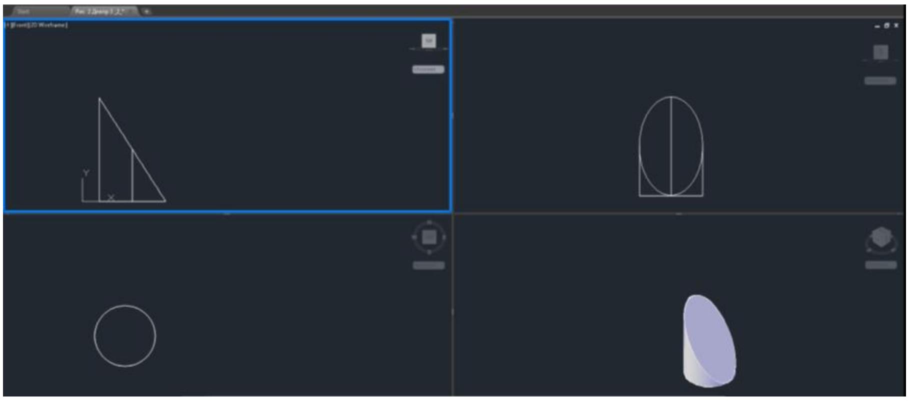

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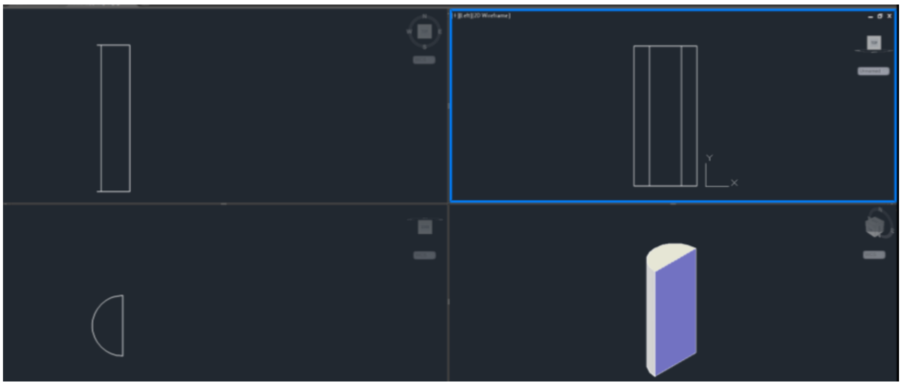
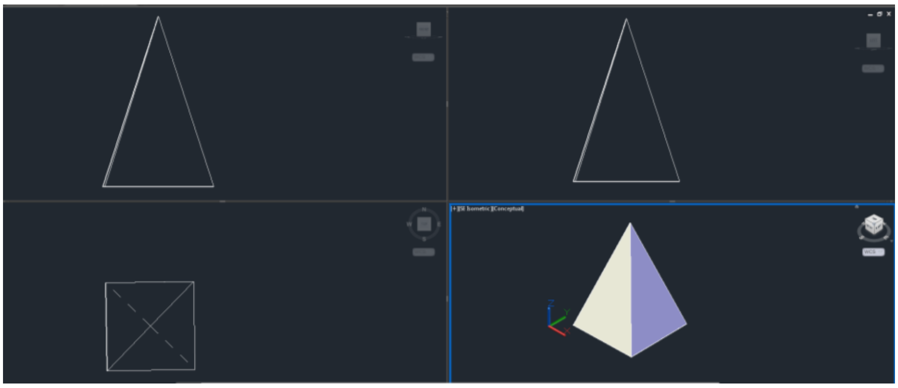
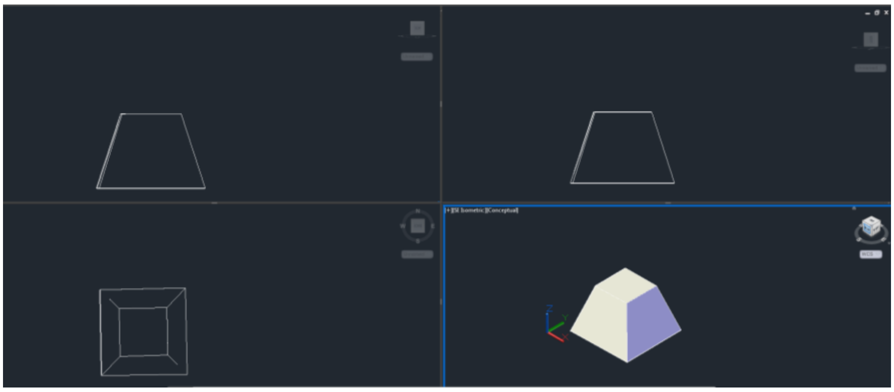


d)

Figure 7 - 3D models and projections of a cylinder on the principal planes truncated by a plane at different angles to the base



a)



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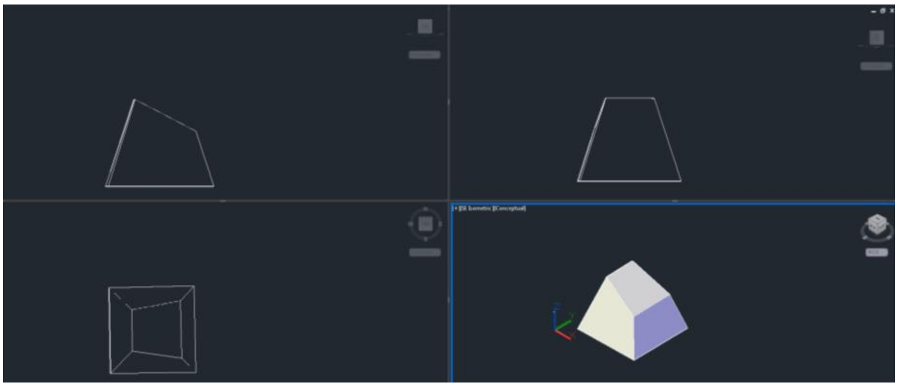

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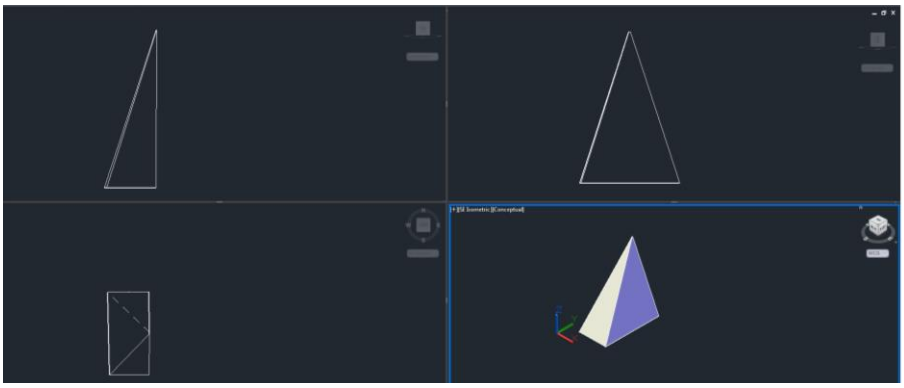

d)

Figure 8 - 3D models and projections of a pyramid on the principal planes truncated by a plane at different angles to the base

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The ease of creating a virtual model contributes to the development of spatial perception and three-dimensional imagination, as well as allows you to master the skills of reading drawings and performing geometric constructions. It is worth emphasizing that AutoCAD also supports the creation of multi-component sections.

As it follows from Fig.6-8, the construction of primitives does not cause special difficulties, gives the opportunity to visualize the obtained cross-sections of figures in the secant plane. This approach contributes to the conscious formation of spatial thinking and the development of volumetric imagination, as well as the acquisition of skills in analyzing drawings and geometric constructions.

Utilizing viewports has significantly streamlined the process of working on intricate and cluttered drawings. Familiarity with these tools and commands will empower students to develop more complex and precise models, ultimately enhancing both the efficiency and quality of their designs. Additionally, students can access AutoCAD for free, as educational versions are available on the developer's website.

In addition, using cross sections in AutoCAD helps you analyze your designs in greater depth. For example, when designing machines and mechanisms, cross sections can help identify potential problems with component placement, such as insufficient space for maintenance or possible conflicts between moving parts. This avoids costly changes at later stages of design and production.

Conclusions. In the world of computer-aided design, AutoCAD plays a key role by providing powerful tools for creating and manipulating geometric objects. Computer visualization is the general name for graphical methods of creating, analyzing, and communicating information. The construction of primitives does not cause special difficulties, gives the opportunity to visualize the obtained cross-sections of figures in the secant plane. This approach contributes to the conscious formation of spatial thinking and the development of volumetric imagination, as well as the acquisition of skills in analyzing drawings and geometric constructions. The use of viewports has made it much easier and faster to work on a complex and cluttered drawing. It is critical for engineers and designers to understand the basic principles of constructing and analyzing cross sections. Knowledge of these tools and commands will enable students to create more complex and accurate models, which in turn will improve the efficiency and quality of design. It should be noted that free student access to AutoCAD is guaranteed due to the availability of educational versions on the developer's website.

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Використання 3D типових тіл-примітивів САПР AutoCad до розв'язку позиційних задач нарисної геометрії

Графічна підготовка студентів технічних спеціальностей є основою інженерної освіти. Аналіз успішності з дисциплін «Нарисна геометрія» та «Інженерна графіка» виявив основну причину зниження результатів за останні роки - недостатність базових знань, набутих у школі. Для покращення засвоєння матеріалу та оптимізації навчального процесу необхідно впроваджувати інноваційні методи, які розвивають просторову уяву та професійні навички. У даній роботі продемонстровано використання комп'ютерної візуалізації для вивчення перерізів тривимірних тіл (конуса, сфери, циліндра) площиною в програмі AutoCAD. Такий підхід дозволяє краще підготувати майбутніх інженерів до розв'язування реальних задач. Простота побудови комп'ютерної моделі дозволяє студентам візуалізувати отримані об'єкти на січній площині, а також їх прямокутні проекції на основні площини.

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