



A PRESENTATION METHOD OF STUDENTS' ASSIGNMENT IN GEOMETRY-INTERSECTION OF TWO SURFACES OF SECOND ORDER

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ABSTRACT

There are two courses concerning geometric topics in the freshman studies at the Faculty of Civil Engineering in Belgrade: Descriptive Geometry for civil engineers and Computational Geometry, for geodetic engineers. In the curriculum of Descriptive Geometry course students are elaborating the topic – intersections of two surfaces of second order (cone and cylinder, two cones, two cylinders, etc.) through tasks in oblique projection, drawing manually. In the other, Computational Geometry course, students are solving the same geometric tasks by applying Boolean operations on 3D solid models of geometric primitives in Auto CAD software. In this paper the combination of these two methods, i.e. drawing procedures will be presented.

The main problem in students' understanding of geometric procedures concerns visualization of 3D objects from 2D images. The authors created unconventional presentation of their geometric assignment provided in AutoCAD software in which 2D drawings (orthographic and oblique projections) and 3D models are united as tools for mastering the topic - intersections of two surfaces of second order - cone and cylinder. The consecutive "steps" of the drawing procedure i.e. geometric solution are conducted by layer control, parallel in 2D and 3D Auto CAD's environment.

The unusual task setting is in the oblique projection, in which given direction of projection ray is parallel to the axis of a cylinder. Several examples of intersection curve are presented in two variations of task settings. Elaboration of such geometric task intended to be a contribution to the collection of solved tasks available for students' use in the website of the Faculty of Civil Engineering in Belgrade.

Keywords: Descriptive geometry task; intersection of cone and cylinder; 4th order curve; constructive geometric procedure; 3D models of surfaces; Boolean operations.

SUBJECT CODE: Education of Descriptive Geometry and Graphics

1. INTRODUCTION

At the Faculty of Civil Engineering in Belgrade, two courses with different teaching methodologies in geometric education exist. The first one, Descriptive geometry (DG) course, in classical terms deals with 2D drawings and 3D perception, combining orthographic and oblique projections as the methods of solving various geometric tasks. The other one, Computational Geometry (CG) course introduces 3D computer environment in solving geometric problems and offers modelling approach. Some geometric procedures (e.g. rotation, symmetry, translation, etc.) are executed by software commands. General characteristics of two mentioned courses are given in Table 1.

Table 1: Overview of the characteristics of two geometry courses in the Faculty of Civil Engineering

<i>Course characteristics</i>	<i>DG COURSE</i>	<i>CG COURSE</i>
<i>Goal group</i>	<i>Civil engineers</i>	<i>Geodetic engineers</i>
<i>Lecturing methodology</i>	<i>Ex cathedra, drawings on the blackboard, Power point presentations</i>	<i>Ex cathedra, Power point presentations</i>
<i>Exercises</i>	<i>2D manual drawings</i>	<i>2D and 3D computer drawings</i>
<i>Tools</i>	<i>Pencil, ruler and compass</i>	<i>Computer software – Auto CAD</i>
<i>Teaching materials</i>	<i>DG handbook, book of geometric tasks with chosen solutions, collection of solved exercises (*.dwg files)</i>	<i>CG handbook, book of geometric tasks with solutions (*.dwg files on CD ROM)</i>
<i>Presentation style</i>	<i>2D drawings supported by 3D representations</i>	<i>2D drawings or 3D model solutions</i>
<i>Presentation methodology</i>	<i>"step by step" drawing procedure conducted by layer control in AutoCAD</i>	<i>Drawing or modelling AutoCAD procedure</i>

Both curriculums elaborate a geometric topic - intersection of two second order surfaces (two cones, two cylinders, as well as cone and cylinder). In DG course students learn geometric drawing procedures of oblique projection for the problem solving, while in CG course the intersection problem is interpreted by Boolean operations of solid models (primitives – cones and cylinders) in Auto CAD software (Obradović, 2010). The idea of the investigation is to combine these two existing presentation methods when solving students' assignment on given topic. Using accurate computer drawings in Auto CAD software, both 2D projections and 3D models, the authors created specific presentation in intention to emphasize the advantages of computer aided 3D geometric problem representations.

2. GEOMETRIC TASK PRESENTATION METHOD – INTERSECTION OF TWO SECOND ORDER SURFACES: CONE AND CYLINDER

Chosen geometric problem, well known from classical references in Descriptive Geometry or Engineering Graphics, can be solved by several classical drawing procedures (e.g. method of cutting planes, line method, auxiliary spheres, etc. (Čučaković, 2010). The criteria for adoption of the methodology are mutual spatial relations of the two chosen surfaces. In classical DG geometric tasks this topic is commonly presented in orthographic or oblique projections. Students rather preferred oblique projection method because of better spatial perception. The experience shown if the presentation method for teaching 2D drawing procedure offers "step by step" guidance, there is a certain assurance of expecting good results in students' mastering the problem (Putz 2001).

However, contemporary methods for mastering Descriptive geometry tasks often use modern technology possibilities, i.e. interactive tools of various software solutions, such as Geogebra, MatLab, AutoCAD (Bokan, 2009; Obradović, 2010; Standiford, 2006), Cabri 3D (Gergelitzova, 2007), etc. Some curriculums even adjusted their name according to a new technology (e.g. Computational geometry). When interactive 3D model presentation added in geometry teaching, the understanding of spatial problems is more reachable goal. AutoCAD software solution was adopted as the presentation "tool" for this research regarding its 3D environment, the possibilities of grouping certain drawing "steps" into layers, as well as for hiding of sufficient overlapping lines (Bokan, 2009). The advantage which enabled manipulation of 3D model in software environment using "orbit" tool and orthographic view palette is not neglectable.

The idea of deepening the students' comprehension of connections between orthographic projections, oblique projection, and 3D computer model provoked the group of older students, authors of the paper, to make some solutions for this problem in an assignment elaborating the topic – intersection of two surfaces of second order.

The science researches have shown that sometimes valuable results appear inspired by a mistake. An often mistake in students' colloquiums is wrong interpretation of the conic sections, where a drawing solution appears as a "hole" inside a cone. Elaboration of the intersection of cone and cylinder in special task setting will be the proper reaction on such nonsense and valuable replay on students' question "What to do if the oblique projection *doesn't work?*"

The presentation is provided inside single Auto CAD drawing file in which layer control manager had the important role. Three filters are set for separate drawing methods: 1-(R) orthographic projections, 2-(O) oblique projection and 3-(S) solid model. The drawing procedure is divided into parts, organized by the order of appearance, and adequately named. The user can turn on/turn of the layers, according to his/her needs and follow the procedure.

2.1 The task setting

If one thinks of the DG goals he/she has to have in mind the definition of its investigation: "Descriptive geometry investigates and applies mappings of three-dimensional space onto a plane drawing board. In order to carry over the constructive methods on plane geometry one gives preference to mappings that makes line in space correspond to lines on the drawing board" (Source: Gellert et al. 1975).

As in the oblique projection one projection plane is in the real size (xz - frontal) while the other two projection planes (xy - horizontal, and yz -profile) appear as "shortened", students' spatial imagination of captured space seems to work properly. However, the understanding of the mapping is not always correct. In order to make it clearer, the task setting is drawn in vertical plane ("drawing board") and mapped to the 3D solid models of the cone and cylinder by oblique projection rays in Auto CAD's 3D environment (Fig.1).

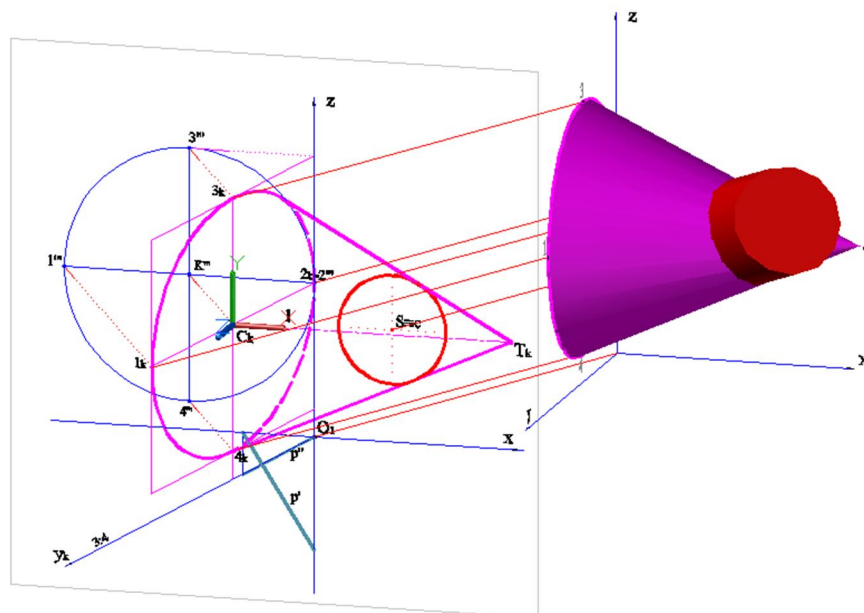


Figure 1: Mapping of 3D solid model and oblique projection

Such establishing of the relations between oblique projection and "real" 3D model should reach visualisation goal of the specific task setting. Although the principles of task solving are the same for each setting, students are often confused when some of given elements change the position. Regarding these reasons two variations of task settings were presented. The first one is such as a base of the cone is set in the profile (yz) plane (Fig. 2a), and the other one where the cone base is set in horizontal (xy) plane (Fig. 2b).

The chosen task setting shown in Fig. 2a is in general oblique projection $\alpha = 30^\circ$, $\gamma = 3:4$ scale. The circular base of a cone, which centre point is $K \in yz$ (profile plane); the axis of the cone $l \parallel x$. The circular base of a cylinder, which centre $S \in xz$ (frontal plane); the axis of the cylinder $c \parallel p$, where p is the projection ray of the oblique projection. Hence, $S \equiv c$. In such task setting the cylinder appears as a circle, and oblique projection is of no use, because the intersecting 4th order curve is overlapping itself into the base circle.

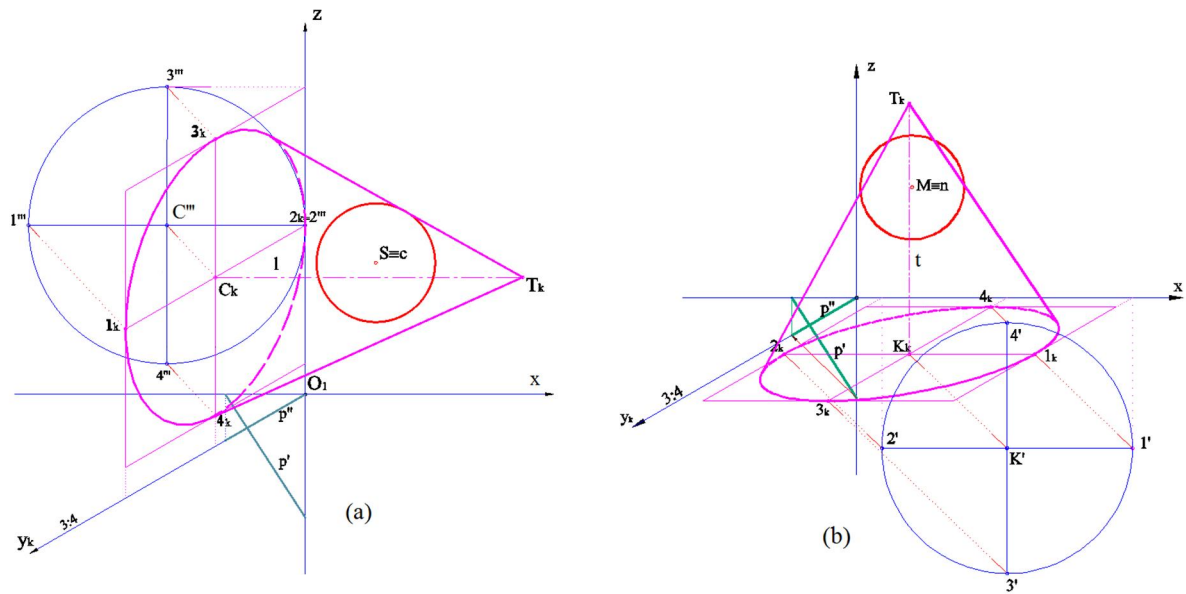


Figure 2: Variations of the task setting in oblique projection; base of the cone is in yz – plane (a); base of the cone is in xy – plane (b)

2.2 Presentation of the task solution in 2D and 3D

Three orthographic projections were used for 2D presentation of the task solution. It is provided in Auto CAD software as a 2D drawing in a way that using layer control a user (student) can follow the drawing procedure, than cutting planes, generatrices in cutting planes, points of intersecting curve, and finally the intersecting curve itself with defined visibility (Fig.3).

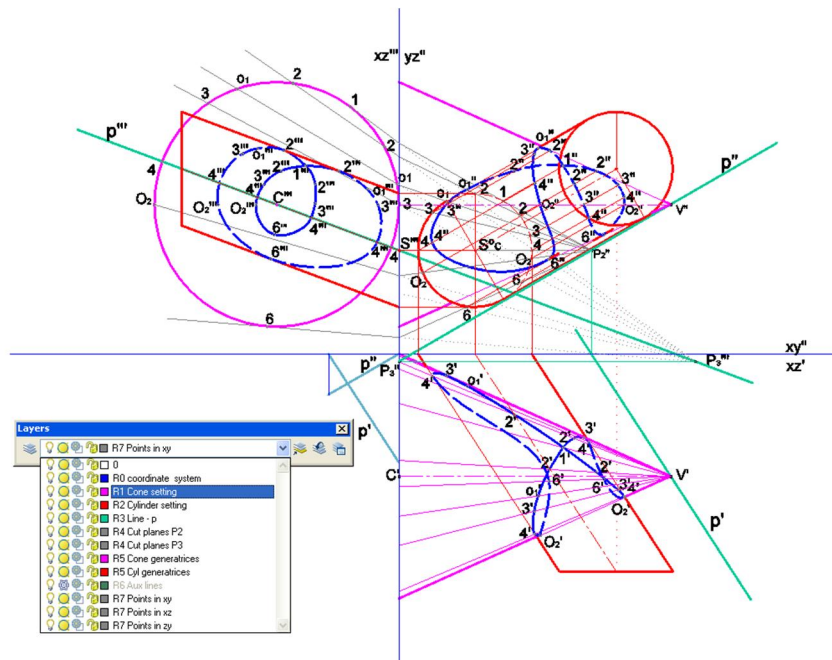


Figure 3: Task solution in orthographic projections

3D presentation of the task solution was prepared in the same drawing file, but as a separate drawing (next to the orthographic solution) in 3D AutoCAD environment containing all the elements which described the drawing procedure. These 3D elements have their own layer organisation (Fig. 4a-b). It is enabled by filters in layer manager. Hence, hiding of all sufficient elements and even the solid models of the cone or cylinder are provided (Fig.4a). Student has the possibility to interact with drawing, e.g. to activate only one solid and intersection curve, for better visualisation of the spatial curve or drawing procedure.

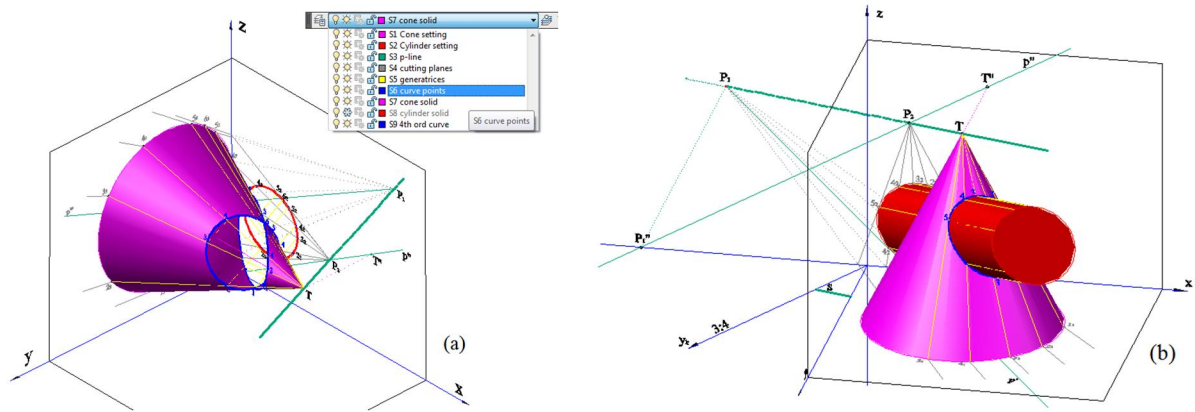


Figure 4: Task solution in "space" model presentation: base of the cone in yz-plane – degeneration of the 4th order curve into two ellipses (a), base of the cone is in xy-plane- 4th order curve is with two branches (b)

In order to present common cases of intersection curves of the cone and cylinder several 3D models were created for each type setting. Four types of the 4th order curves are presented: curve with two branches (Fig. 5a-b), curve with single branch and self intersection point (Fig. 5c) and degenerated curve – splitted into two ellipses (Fig. 5d).

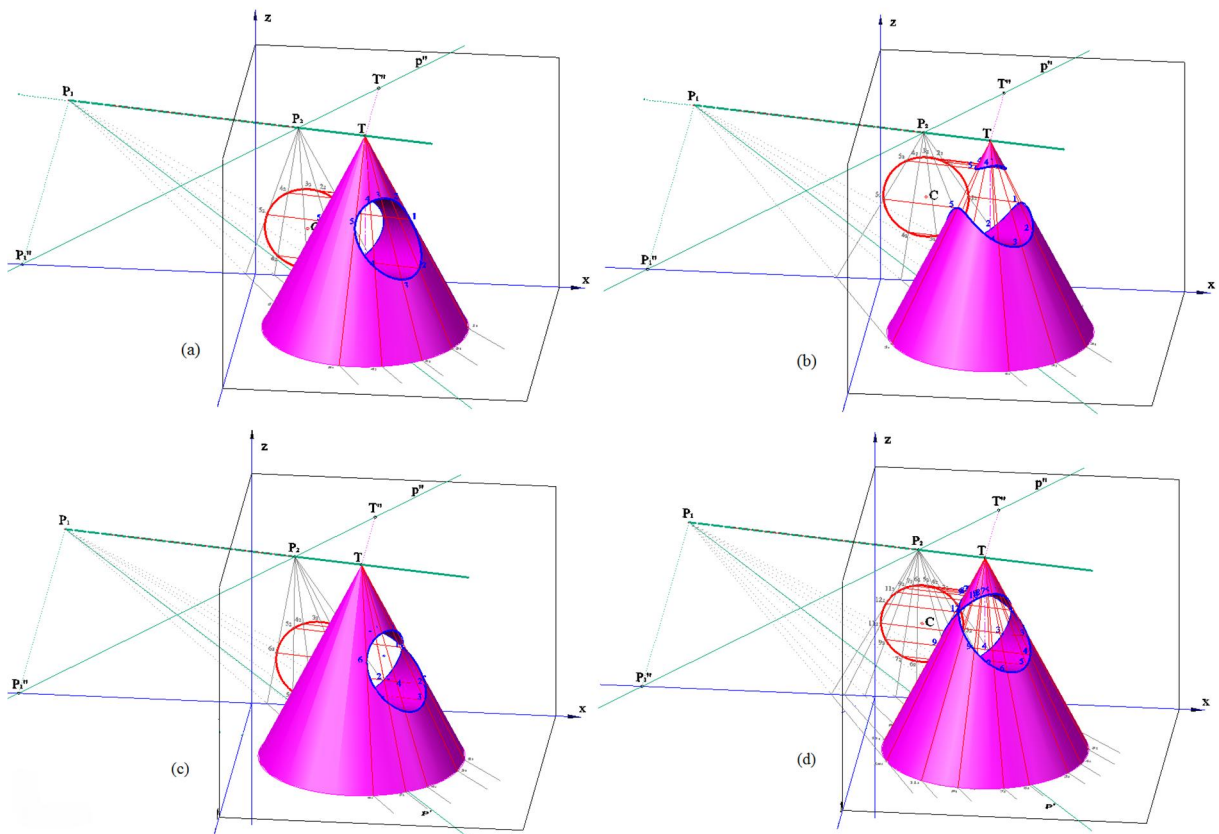


Figure. 5 a-d: Variants of intersecting curves – space model solutions. Type of setting where the cone base is in xy-plane. 4th order curve with two branches (a) and (b); 4th order curve with one branch and self-intersecting point (c); 4th order curve degenerated (d)

Special views were captured as "named views" in Auto CAD (named "*the hole*") in order to present the "*moment*" of overlapping of the oblique projection and spatial 3D model. Here 3D appearance of the intersection shown the "*nonsense*" of oblique projection in considered setting (Fig.6).

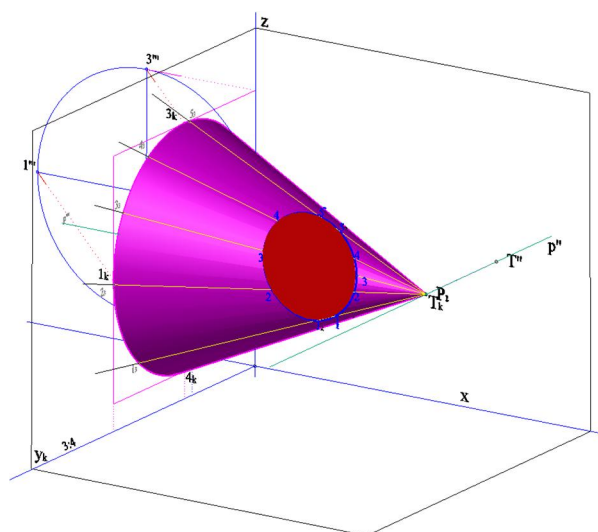


Figure. 6: 3D model view (named view "the hole") – oblique projection overlapping 3D model.

CONCLUSION

The students' research here presented offered a presentation method of the geometric topic – intersection of two surfaces of second order (cone and cylinder). The possibilities of using AutoCAD 3D environment for teaching/learning process in Descriptive Geometry course were shown. Students, authors of the paper applied their skills gained in DG and CG courses and merged methodologies in order to present the chosen geometric topic. By combining 2D drawings in projections both oblique and orthographic with 3D models, satisfactory results were obtained in the domain of presentation methodology. Drawing procedures were presented by using layer control tool-palette in AutoCAD software, which enabled step by step guidance through the task. The mapping of the oblique projection and 3D models were presented in 3D software environment. Several variations of the resulting 4th order curve were elaborated in two types of task setting in unique drawing file.

The advantage of this presentation method lays in the possibility of a user (student) to interact with the content, i.e. activate/deactivate parts of the drawing, manipulate in 3D, capture characteristic views, etc. With proper explanation at lessons and a short users guide through AutoCAD's tool palettes, a student will be able to understand, draw and visualize geometric topic. This work made the significant contribution to the existing collections of the task solutions at the website of the Civil Engineering Faculty inside DG learning materials.

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