Journal homepage: https://itce.vn.ua/en

Information Technologies and Computer Engineering **Vol. 23, No. 2. 2026**

Article's History: Received: 26.12.2025 Revised: 05.05.2026
Accepted: 25.06.2026 Published: 03.08.2026

ISSN 1999-9941; e-ISSN 2078-6387
UDC 519.85
DOI: 10.31649/vitce/2.2026.09

3D visualisation of cylindrical bodies in the Maple CAS: Original methods and techniques

Volodymyr Mykhalevych*
Doctor of Technical Sciences, Professor
Vinnytsya National Technical University
21021, 95 Khmelnytske Shose Str., Vinnytsya, Ukraine
https://orcid.org/0000-0003-1557-7331

Oksana Tiutiunnyk
PhD in Pedagogical Sciences, Associate Professor
Vinnytsya National Technical University
21021, 95 Khmelnytske Shose Str., Vinnytsya, Ukraine
https://orcid.org/0000-0002-8544-4246

Yuriy Dobraniuk
PhD in Technical Sciences, Associate Professor
Vinnytsya National Technical University
21021, 95 Khmelnytske Shose Str., Vinnytsya, Ukraine
https://orcid.org/0000-0001-6387-6331

Maiia Kovalchuk
Doctor of Technical Sciences, Professor
Vinnytsya National Technical University
21021, 95 Khmelnytske Shose Str., Vinnytsya, Ukraine
https://orcid.org/0000-0002-1895-1715

Abstract. The relevance of this topic stems from the growing need to utilise modern tools of computational mathematics to enhance the efficiency of analysing, modelling and visualising complex spatial objects. The aim of this work was to develop an original method for the three-dimensional visualisation of cylindrical solids within the Maple computer algebra system. The proposed approach was based on structuring the mathematical model of a cylindrical body into separate elements – a projection plane, guide curves, generatrix segments and boundary surfaces – with their subsequent integration into a single 3D model. The study employed the basic Maple tools (`plot3d, spacecurve, plottools[line], display`), which enabled the software implementation of individual elements of the spatial object and their step-by-step combination into a complete model of a cylindrical body in order to create a clear three-dimensional representation. A number of original techniques were developed for constructing planar and spatial guides defined by a pair of intersecting curves forming a closed region, families of generators in the form of straight-line segments to create a transparent lateral cylindrical surface, as well as methods for surface visualisation that allow adaptive modification of model parameters, display of intermediate construction stages, and control over the relative arrangement of its elements. Examples of the practical implementation of the method for constructing cylindrical bodies based on typical higher mathematics problems were presented, confirming the effectiveness and convenience of the developed approach. It was shown that the proposed method has a universal character and may be used not only in the educational process but also in scientific research and applied engineering tasks requiring accurate and clear 3D visualisation of multicomponent bodies. The practical value of the work lies in the fact that the developed approach may be regarded as a component of information technology for the three-dimensional visualisation of geometric objects in computer algebra systems, combining ease of implementation, flexibility of modelling, and high informational value of graphical results

Keywords: computer algebra systems; parametric curves and surfaces; geometric modelling; educational technologies in mathematics; applied mathematical modelling; engineering visualisation

Suggested Citation:
Mykhalevych, V., Tiutiunnyk, O., Dobraniuk, Yu., & Kovalchuk, M. (2026). 3D visualisation of cylindrical bodies in the Maple CAS: Original methods and techniques. *Information Technologies and Computer Engineering*, 23(2), 9-23. doi: 10.31649/vitce/2.2026.09.

*Corresponding author (*mykhalevych@vntu.edu.ua*)

Introduction

The problem of improving the effectiveness of teaching mathematical disciplines in higher education institutions is determined by the increasing complexity of educational material and the need to develop students' analytical and spatial thinking. One of the promising directions for modernising the educational process is the widespread implementation of computer algebra systems (CAS), particularly Maple. The use of such tools provides opportunities for the interactive construction, visualisation, and analysis of complex mathematical objects, significantly enhancing clarity and promoting a deeper understanding of abstract concepts.

The task of three-dimensional visualisation of cylindrical bodies is one of the fundamental problems in applied and theoretical mathematics. It arises not only in classical educational topics related to the calculation of multiple and surface integrals, but also in a wide range of scientific, engineering, and technological problems. In particular, the construction of a surface of limiting plastic deformations as a function of two dimensionless stress-state invariants is a typical example requiring accurate and clear visualisation of a complex spatial object (Serdiuk *et al.*, 2021). The rapid growth in the computational capabilities of modern computer algebra systems, particularly Maple, opens new possibilities for automating the construction and visualisation of such objects. At the same time, the effective use of Maple in similar tasks requires the development of specialised techniques and approaches. A substantial body of results devoted to the application of standard Maple tools for constructing three-dimensional images has accumulated in the scientific and methodological literature, and this direction has been actively developing since the late twentieth century (Kusno, 2022).

D.A. Espejo-Peña & A.I. Flores-Osorio (2023) proposed an approach to constructing surfaces in cylindrical coordinates using augmented reality technologies within the GeoGebra environment. The authors demonstrated that combining mathematical rigour with visual intuition facilitates a better understanding of complex geometric structures. At the same time, the study focuses on modelling a specific applied object – a sedimentation tank – which limits the generality of the results and does not cover a broader range of tasks in the three-dimensional visualisation of cylindrical solids.

D. Lieban & R.W. Bueno (2022) analysed approaches to studying cross-sections of three-dimensional bodies in the context of the historical development of mathematical concepts, combining the philosophy of the "three worlds of mathematics" – symbolic, visual and formal – with the application of modern computer technologies. The authors demonstrated that the integration of digital tools promotes the development of systematic thinking when working with spatial models. However, their findings served more to justify the need for improvements in specialised information technologies for three-dimensional visualisation than to propose specific software solutions. Similar conclusions are found in the work of Z. Lavicza *et al.* (2023), where, based on empirical studies of the use of GeoGebra 3D, it was demonstrated that active manipulation of three-dimensional models promotes the development of spatial thinking and a deeper understanding of mathematical concepts. However, the study was predominantly pedagogically oriented and did not consider aspects of the algorithmic and software implementation of methods for constructing complex spatial objects.

The study by R. Ipanaqué-Chero *et al.* (2025) presented the BSplineSolid package for creating and visualising complex three-dimensional objects using rational three-variable B-splines in the Mathematica environment. The methodology was geared towards the high-precision reproduction of complex surfaces in scientific and engineering applications. However, the structural elements of cylindrical solids are not treated as a separate modelling object, which complicates the element-by-element visualisation of such geometric structures.

The study by X. Liu *et al*. (2023) reviewed modern methods for optimising large 3D models for online visualisation in Web3D environments. The authors analysed approaches to reducing geometric redundancy, optimising rendering, and applying machine learning algorithms to reduce computational load. However, the study focused on the challenges of efficiently transmitting and rendering complex scenes and did not address the issue of mathematically sound construction of spatial bodies based on analytical models.

O.S. Turzhanska (2023) has made a significant contribution to the development of the theoretical and methodological foundations for the use of mathematical and information technologies in higher education institutions. She investigated the capabilities of computer algebra systems in the creation of information technologies for constructing mathematical models and their visualisation. At the same time, specialised issues concerning the three-dimensional visualisation of particular classes of spatial bodies, especially cylindrical ones, were not the subject of separate analysis.

In the works of V.F. Chelombitko & V.P. Tkachenko (2022) and V.F. Chelombitko (2024), mathematical models and information technologies for the implementation in the Maple environment of geometric security patterns – complex planar graphic compositions formed by means of parametric modelling, R-functions and the apparatus of complex variables – are considered, without transitioning to three-dimensional visualisation. A similar trend can be observed in the work of V. Mykhalevych *et al*. (2023), where, due to the lack of established methods for visual three-dimensional visualisation, the analysis of the volumetric stress state was limited to the two-dimensional case.

Thus, an analysis of current research has demonstrated a significant body of work in the field of three-dimensional modelling and the application of CAS, yet has revealed a shortage of studies aimed at developing specialised methods for element-by-element visualisation of cylindrical bodies specifically within the Maple environment. This highlights the relevance of developing an original method for 3D visualisation of cylindrical bodies, which combines the structuring of the mathematical model with flexible programming techniques and ensures a high level of clarity. The aim of this article was to develop a method for three-dimensional visualisation of cylindrical bodies in the Maple computer algebra system to improve clarity when solving educational, scientific and engineering problems. In the course of the research, the following tasks were addressed: to analyse the geometric and mathematical characteristics of cylindrical bodies and to structure their mathematical model into separate components; to propose a method for constructing cylindrical bodies in Maple, based on a system of individual techniques and methods of software implementation, which provides element-by-element three-dimensional visualisation of the structured model; to evaluate the effectiveness of the proposed method in terms of improving visualisation during the modelling and analysis of relevant problems.

Materials and Methods

To accomplish the stated objectives, general approaches to the mathematical description of cylindrical bodies frequently encountered in educational, scientific, and engineering problems were first applied. Such an analysis made it possible to structure the model of a cylindrical body into separate geometric components, each of which is subject to visualisation. A method for the element-by-element three-dimensional construction of these components in the Maple environment using original programming implementation techniques is proposed. Each stage is accompanied by examples of graphical visualisation illustrating the proposed techniques.

The developed methodology for constructing spatial bodies was based on the use of the following fundamental definitions. A cylindrical surface is a surface generated by the motion of a generator – a vertical straight line parallel to the *Oz* axis. A guide curve is any curve intersected by the generator of the cylindrical surface in all its positions. Let a region *P* bounded by a closed contour *L* be defined in the *Oxy* plane. In this study, a cylindrical body is understood as a geometric solid bounded:

- below by the region *P*;
- laterally by a cylindrical surface having *L* as its guide curve;
- above by a portion of the surface *S* defined by the equation:

$$z=f(x, y), \tag{1}$$

where z – a function of two independent variables x and y.

It is assumed that function (1) is defined, continuous and non-negative on the domain *P*.

In view of the above definition of a cylindrical body, it may be stated that its mathematical model is multicomponent and consists of the following equations:

- the equation of the surface S in the form;
- the equation of the *Oxy* plane: $z=0$;
- the equation of the guide curve *L*;
- the equation of the cylindrical surface *Q*;
- the equation of the curve *C*, which forms the boundary of the portion of the surface *S* and is generated as a result of its intersection with the cylindrical surface *Q*. Since the curve *C* belongs to the lateral surface of the cylinder *Q*, it simultaneously serves as its guide curve, limiting the cylindrical surface from above.

The Maple system does not contain a single standard command providing automated construction of a three-dimensional image of a cylindrical body. Consequently, the visualisation process requires step-by-step implementation using a number of tools, each responsible for a separate stage in constructing the geometric model. Thus, one of the key elements of the method for the three-dimensional visualisation of a cylindrical body proposed in this work is the structuring of its mathematical model into separate components. The subsequent stages of constructing the 3D visualisation of a cylindrical body involved the development of methods, approaches, and techniques for visualising each individual element of the body within the Maple CAS.

To implement the element-by-element three-dimensional visualisation of the structured mathematical model of a cylindrical body in the Maple environment, the standard command `plot3d`, intended for constructing surfaces defined by analytical relations, was employed. Its use made it possible to realise individual model components – the projection plane, the integration region, and surface (1) – followed by their combination into a unified spatial composition.

In general form, the command has the structure:

```
plot3d(f(x,y), x = a..b, y = g1(x).. g2(x), options),
```

where $x = a..b$ – the range of variation of the variable x; $y = g_1(x)..g_2(x)$ – the limits of variation of the variable y, which may depend on x and define a curvilinear region; the options specify the parameters of the graphical display.

The *OXY* plane was implemented as a surface with a zero ordinate value:

```
plot3d(0, x = a..b, y = c..d, color = grey,
grid = [10,10], axes = boxed,
scaling = constrained, orientation = [135,70]).
```

The zero analytical expression defines the plane $z = 0$. In Maple, the colour of graphical objects can be specified in two main ways: using standard named colours or via their numerical representation in the RGB model. The option color=grey defines a standard grey colour with fixed parameters determined by the Maple system. This method is simple to use; however, it does not allow precise adjustment of the saturation and brightness of the shade. The grid parameter determines the density of the computational grid when constructing the surface. Increasing the parameter values improves the accuracy and smoothness of the image, but increases computational costs. The axes=boxed parameter displays the coordinate axes as a spatial frame, which delimits the construction area and facilitates spatial orientation when analysing a three-dimensional image. The parameter scaling=constrained is used to maintain the same scaling along all coordinate axes, ensuring the geometric correctness of the display. The parameter orientation allows a reasonable viewing angle of the scene to be set. Construction of the projection of the region onto the *OXY* plane. The projection of the closed region *P*, bounded by the curves $y=g_1(x)$ and $y=g_2(x)$ is constructed using a surface with a zero application and variable integration limits:

```
plot3d(0, x=X1..X2, y=g1(x)..g2(x),
color=[0.95,0.95,0.95], grid=[10,10],
axes=normal, scaling=constrained,
orientation=[-80,38]).
```

The variable boundaries $g_1(x)$.. $g_1(x)$ allow for the direct visualisation of the domain of surface (1), bounded by two curves that intersect at two points and form a closed domain for a two-variable function in the *Oxy* plane. The values of the boundaries *X1, X2* are found as solutions to the nonlinear equation $g_1(x) = g_2(x)$, which is implemented using the standard command solve solve({g_1(x) = g_2(x)},{x}). This approach assumes the existence of at least two distinct solutions to the specified nonlinear equation. A light shade of colour, color = [0.95,0.95,0.95] is used to visually distinguish the projection from other elements of the model. The construction of surface (1) is implemented using the following command:

```
plot3d(f(x,y), x=X1..X2, y=g1(x).. g2(x),
color=magenta, grid=[20,20], axes=normal,
scaling=constrained, orientation=[-80,38],
style=wireframe).
```

The colour color=magenta was chosen to clearly highlight surface (1) within the overall composition of the cylindrical body. The increased grid density (grid = [20,20]) ensured a more detailed representation of the surface shape. The axes=normal option was used for the standard display of coordinate axes, which facilitated the correct spatial perception of the surface as a separate component of the model. The style=wireframe option was applied to emphasise the surface structure and ensure visual transparency when combined with other elements of the cylindrical body. Thus, the plot3d command was used as the basic tool for the step-by-step implementation of individual components of the structured mathematical model. Its combination with other Maple graphical procedures ensured consistent scaling, correct spatial orientation and a high level of clarity during the construction of the cylindrical body.

An important technique for three-dimensional visualisation of cylindrical bodies in the Maple computer algebra system is the construction of spatial lines: lines of intersection of the cylindrical surface with surface (1) and their projections onto the *Oxy* plane, which serves as a guide along which the generatrices of the cylindrical surface move. The spacecurve command is used to construct spatial curves in the Maple software environment. This command belongs to the plots package and allows the visualisation of a three-dimensional curve defined by three parametric equations: $x = x(t)$, $y = t(t)$, $z = z(t)$, where t – where t is a parameter that varies over a specified range. The limits of this range, t_1 and t_2, are determined by the conditions: $x(t_1) = X_1$, $x(t_2) = X_2$. The command syntax is: spacecurve([x(t), y(t), z(t), t = t_1...t_2, options]), where options – where options are additional parameters for plotting the graph. The command supports the use of multiple sets of parametric expressions, allowing several spatial curves to be plotted simultaneously on a single graph. The following construction was created to visualise the guide line *L*:

```
spacecurve(({[t, g1(t), 0, t=t1.. t2],[t, g2(t),
0, t=t1.. t2]}, color=green, thickness=k,
axes=normal, orientation=[-80,38],
scaling=constrained),
```

where `thickness` – a parameter used to specify the line thickness of a spatial curve on a graph. It determines the visual clarity of the curve and, together with the choice of the `color` option, affects its visibility within the overall composition of the three-dimensional image.

Similarly, the visualisation of line *C* is implemented using the construction:

```
spacecurve(({[t, g1(t), z(t, g1(t)),
t=t1.. t2],[t, g2(t), z(t, g2(t),
t=t1.. t2]}, options).
```

Regarding the construction of the cylindrical surface *Q*, it should be noted that the generatrices of the surface in question are bounded below by the guide line *L*, which lies in the *Oxy* plane, and above by the spatial curve *C*. The cylindrical surface is formed by moving a vertical segment (generatrice) along these guide lines. In this process, the coordinates of its endpoints vary in accordance with the parameterisation of the curves *L* and *C*. Note that the abscissa of the lower endpoint remains constant and equals zero. The parametric equations of the generating segment in its current position, corresponding to each of the individual sections of the guide curves, are as follows:

$$
\begin{cases} x = t_1 + t_i(t_2 - t_1), \\ y = g_1\big(t_1 + t_i(t_2 - t_1)\big), & t \in [0.1], \\ z = t \cdot f\Big(t_i, g_1\big(t_1 + t_i(t_2 - t_1)\big)\Big), \end{cases}
$$
$$
\begin{cases} x = t_1 + t_i(t_2 - t_1), \\ y = g_2\big(t_1 + t_i(t_2 - t_1)\big), \quad t \in [0.1], \\ z = t \cdot f\Big(t_i, g_2\big(t_1 + t_i(t_2 - t_1)\big)\Big), \quad t_i \in [0.1]. \end{cases} \tag{2}
$$

The lateral surface of the cylindrical body was visualised as a set of vertical straight lines (generators) that reflect its geometric structure. This approach ensured the visual transparency of the model and made it possible to clearly trace the relative positions of all elements of the cylindrical body. To construct a set of generatrices, the universal command for constructing spatial curves, spacecurve, can be used. However, in this case, the plottools[line], command is more convenient, as it is used to construct a line segment in three-dimensional space based on the coordinates of its endpoints. It is part of the plottools package and is used as an auxiliary tool when creating complex spatial compositions. The general syntax of the command is as follows:

```
plottools[line]([x1,y1,z1], [x2,y2,z2],
options),
```

where `[x1,y1,z1]` i `[x2,y2,z2]` – the coordinates of the start and end points of the line segment, and the options `(color, thickness, linestyle etc.)` determine the parameters of its graphical representation.

For the three-dimensional visualisation of the lateral surface of a cylindrical body, specialised code was developed based on mathematical model (2) and the use of the plottools[line] command.

```
numLines := N:
for i from 0 to numLines do
ti :=(i/numLines)*1;
lines1[i]:=plottools[line]
([t1+ti*(t2-t1),g1(t1+ti*(t2-t1)),0],
[t1+ti*(t2-t1),g1(t1+ti*(t2-t1)),
f(t1+ti*(t2-t1),g1(t1+ti*(t2-t1)))],
color=blue, linestyle=1, thickness=1);
end do:

numLines := N:
for i from 0 to numLines do
ti :=(i/numLines)*1;
lines1[i]:=plottools[line]
([t1+ti*(t2-t1),g2(t1+ti*(t2-t1)),
0], [t1+ti*(t2-t1),g2(t1+ti*(t2-
t1)),f(t1+ti*(t2-t1),g2(t1+ti*(t2-t1)))],
color=blue, linestyle=1, thickness=1);
end do:
```

The density of the generating lines along the guide can be adjusted by setting the appropriate value for the variable `numLines`. To combine separately constructed graphical objects into a single three-dimensional composition, the `plots[display]` command was used, which allows several graphs created by different commands (in particular `plot3d, spacecurve, plottools[line]`), to be displayed simultaneously, whilst preserving their relative spatial arrangement. The general syntax of the command is as follows:

```
plots[display]([obj1,
obj2, …], options),
```

where `obj1, obj2, ...` – pre-constructed graphical objects, and the options define the parameters for their joint display. The approach used provides accurate and intuitive three-dimensional visualisation of cylindrical bodies, enabling the effective solution of problems in mathematical modelling and geometric analysis. The developed methods allow for a detailed representation of the model components, which significantly improves the quality of solutions to problems in higher mathematics, scientific and engineering disciplines.

Results and Discussion

This section presents the results of applying the proposed method for three-dimensional visualisation of cylindrical bodies in the Maple environment and their analysis. Particular attention is paid to verifying the effectiveness of the developed methods and techniques in problems related to the modelling of spatial regions and the calculation of body volumes using multiple integrals. To illustrate the capabilities of the proposed methodology, its application is examined using a specific example of a problem involving the calculation of the volume of a solid bounded by the given surfaces: $z=0$, $z=x^4+y^2$, $x=y^{1/2}$, $x=y^2$.

Usually, in such problems, it is suggested to draw the given solid and its projection onto the *Oxy* plane. Thus, all steps for constructing the given cylindrical solid are considered. In the first step, the *Oxy* plane (Fig. 1) is constructed using the command:

```
restart:
plot3d(0, x=0..1, y=0..1, color=grey,
grid=[10,10], axes=boxed, scaling=constrained,
orientation=[135,70]);
PlaneOXY := %:
```

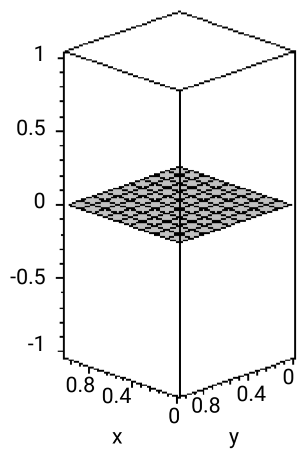


Figure 1. Visualisation of the constructed coordinate plane *Oxy*

Source: compiled by the authors

Increasing the grid parameter results in: a more detailed reproduction of the surface's geometric shape; smoother contours and a reduction in image jaggedness; and a more accurate representation of local features (curves and bends). At the same time, an excessive increase in mesh density increases the computational load and may slow down the generation of the graph without a significant improvement in visual quality. In the study, the grid parameter was selected experimentally, taking into account the complexity of the surface and the requirements for visual clarity. For most constructions, values of the order grid=[10,10] or grid=[20,20] were used, which ensured sufficient detail with a moderate computational load. Creating a procedure to execute the relevant commands simplifies the adjustment of the ranges of variables *x* and *y* (Fig. 2).

```
PlaneOXYi:=proc(z,X1,X2,Y1,Y2)
plot3d(z, x=X1..X2, y=Y1..Y2, color=grey,
grid=[10,10], axes=boxed, scaling=constrained,
orientation=[-41,68]);
end proc;
X1:=-1:X2:=1:Y1:=-0.5:Y2:=2:
PlaneOXYi(0,X1,X2,Y1,Y2);
PlaneOXY := %:
#Restore the previous ranges of the variables
X1:=0:X2:=1:Y1:=0:Y2:=1:
PlaneOXY :=PlaneOXYi(0,X1,X2,Y1,Y2):
```

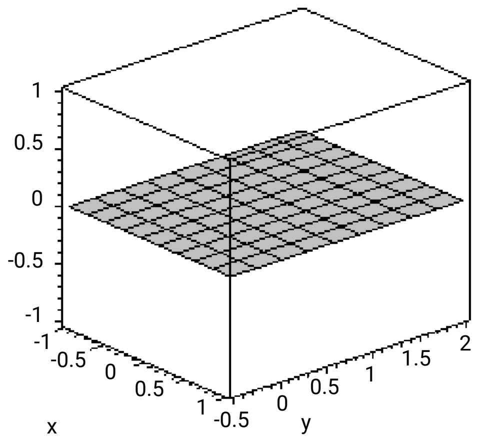


Figure 2. Visualisation of the constructed coordinate plane *Oxy* using the procedure
Source: compiled by the authors

In the problem under consideration, the region *P* is defined by the equations of two curves $x=y^{1/2}$, $x=y$, which form the contour *L* that bounds this region in the $z=0$ plane. To write the parametric equations of the curves forming the contour in full, the points of intersection of these lines have been found:

```
solve({x^(1/2)=x^2},{x});sols1:=%:
subs(%[1],y=x^(1/2)),%[1][]],
[subs(%[2],y=x^2),%[2][]];
```

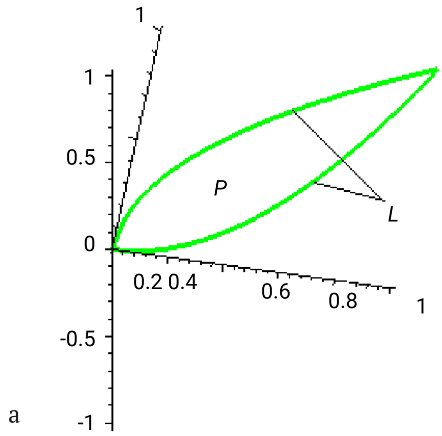
$$\{x=0\}, \{x=1\}$$
$$[y=0, x=0], [y=1, x=1].$$

Thus, the boundary of region P is closed and formed by two lines intersecting at two points. The parametric equations of these lines in space (2) take the form:

$$\begin{cases} x = t, \\ x = \sqrt{t}, \quad t \in [0.1]. \\ z = 0, \end{cases} \qquad \begin{cases} x = t, \\ x = t^2, \quad t \in [0.1]. \\ z = 0, \end{cases} \tag{3}$$

The corresponding Maple code was used to construct the image. Figure 3 shows the result of its execution.

```
plots[spacecurve]({[t, sqrt(t), 0,t=0..1],
[t, t^2, 0,t=0..1]}, color=green, thickness=3,
axes=normal, orientation=[-80,38],
scaling=constrained); GuideCS:=%:
```




```
plots[display]([PlaneOXY,GuideCS], axes=frame,
orientation=[-56,41]);
```

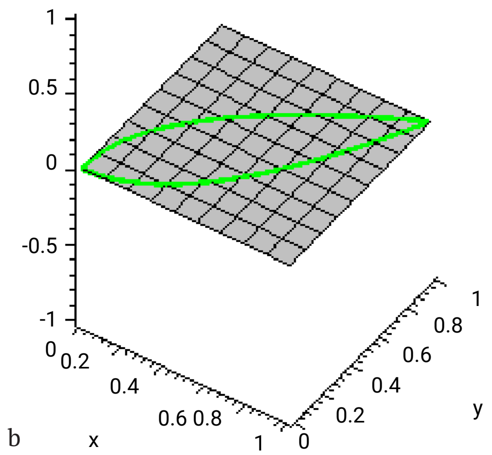


Figure 3. Visualisation of the constructed contour of region *P*
Note: a – contour lines without visualisation of the plane in which they are located (`orientation = [-80, 38], axes = normal`); b – contour lines together with visualisation of the fragment of the plane in which they are located (`orientation =[-56, 41], axes = frame`)
Source: compiled by the authors

Increasing the value of the `thickness` parameter ensures: better visibility of curves in complex spatial compositions; clearer visual distinction of guides and intersection lines; and improved perception of the model's structure when combined with surfaces. Excessively increasing the thickness may, however, lead to partial overlap of neighbouring image elements. In this study, a value of `thickness=3` was chosen, which ensured sufficient clarity of the curves without overloading the graphical composition.

The third step consists in constructing the region P in the Oxy plane, implemented using the following code fragment:

```
X1:=0:X2:=1:
plot3d(0, x=X1..X2, y=x^2..sqrt(x), color=[
0.95, 0.95, 0.95], grid=[10,10], axes=normal,
scaling=constrained, orientation=[-80,38]);
zeroP:= %:
```

where $x=x_1...x_2$ – the range of variation of the variable x from 0 to 1; $y=x^2..\sqrt{x}$ – the range of variation of the variable y, bounded by two curves: $y=x^2$ and $y=\sqrt{x}$ (this defines the region P in the Oxy plane; `color=[ 0.95, 0.95, 0.95]` – a light grey colour for the projection, ensuring visual neutrality and avoiding visual clutter; axes=normal – displays the standard X, Y, Z coordinate axes; `orientation=[-80,38]` – determines the scene orientation, allowing convenient viewing of the projection from above. The given code fragment may serve as a universal template for constructing in Maple the projection of an arbitrary planar region bounded by a pair of functionally defined curves. Visualisation of all three objects together – the Oxy coordinate plane, the plane P together with its boundary L (Fig. 4):

```
plots[display]([PlaneOXY,GuideCS,zeroP],
orientation=[-65,47]);
```

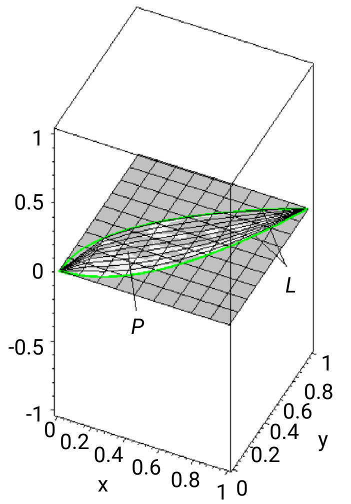


Figure 4. Visualisation of the constructed coordinate plane Oxy, region P, together with its boundary L
Source: compiled by the authors

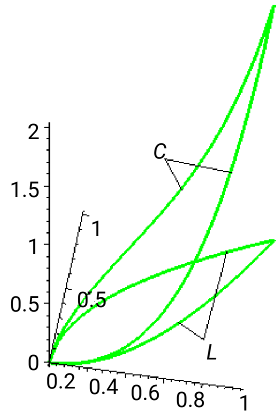
The fourth step involves constructing the spatial curve C, which defines the contour of the cylindrical body in three-dimensional space. Its projection onto the Oxy plane is the previously constructed curve L; thus, curve C also serves as a guide curve and is defined as a pair of spatial parametrically specified curves, each corresponding to a boundary curve of region P and, unlike line L, belonging to the surface described by function (1). This pair of spatial curves on the surface $z=x^4+y^2$ is defined on the basis of the parameterisation of the boundary curves of region P in the Oxy plane:

$$\begin{cases} x = t, \\ x = \sqrt{t}, \\ z = t^4 + t, \end{cases} \quad t \in [0.1]. \qquad \begin{cases} x = t, \\ x = t^2, \\ z = 2t^4, \end{cases} \quad t \in [0.1]. \tag{4}$$

The following code fragment is intended for the visualisation of both contours L and C, presented in Figure 5.

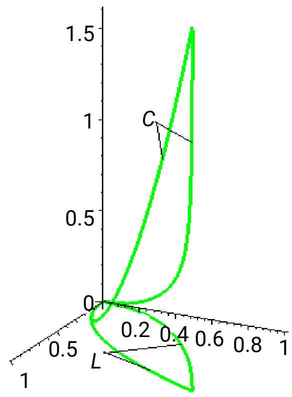
```
plots[spacecurve[t,sqrt(t), t^4+t,t=0..1],[t,
t^2, 2*t^4,t=0..1]}, color=green, thickness=3,
axes=normal, orientation=[-80,38],
scaling=constrained):
GuideCS:=%:

Plots[display]([guidecs,guidecc]);
```



a

```
plots[display]([guidecs,guidecc],
orientation=[27,70]);
```



b

Figure 5. Construction of the contour of the cylindrical body in three-dimensional space (curve C) and its projection onto the Oxy plane (curve L)
Note: a – spatial view of the contour at the viewing angle `orientation = [-80,38]`; b – alternative image perspective at `orientation = [27,70]`
Source: compiled by the authors

The figure presents two versions of the image differing in the position of the scene relative to the coordinate system, making it possible to clearly trace the mutual arrangement of the spatial curve C and its projection L onto the Oxy plane. Such a presentation contributes to a better understanding of the geometric structure of the contour of the cylindrical body and the features of its spatial formation. Changing the viewing angle provides a clearer representation of the spatial arrangement of curve *C* relative to the *Oxy* plane and makes it possible to verify the correctness of the construction of its projection *L*.

The fifth step involves constructing the portion of surface S bounded by the closed contour *C*. For this purpose, the following command was applied:

```
plot3d(x^4+y^2, x=X1..X2, y=x^2..sqrt(x),
color= magenta, grid=[20,20], axes=normal,
scaling=constrained, orientation=[-80,38],
style=wireframe):
surfaceSc:= %:
```

```
plots[display]([PlaneOXY,GuideCS,
zeroP, GuideCC,surfaceSc],
orientation=[-94,70]);
```

Taking into account the results obtained in the fifth step, all constructed elements of the cylindrical body were visualised within a single three-dimensional composition: the coordinate plane *Oxy*, the plane $z = 0$ together with its boundary, and the portion of surface *S* bounded by the closed contour *C* (Fig. 6). Combining these elements within a single graphical image provided a clear representation of their mutual spatial arrangement and made it possible to trace the consistency of the individual construction stages. Such an approach contributed to a holistic perception of the geometric structure of the cylindrical body and facilitated analysis of the relationships between its principal components:

```
plots[display]([PlaneOXY,GuideCS, zeroP,
GuideCC,surfaceSc], orientation=[27,70]);
```

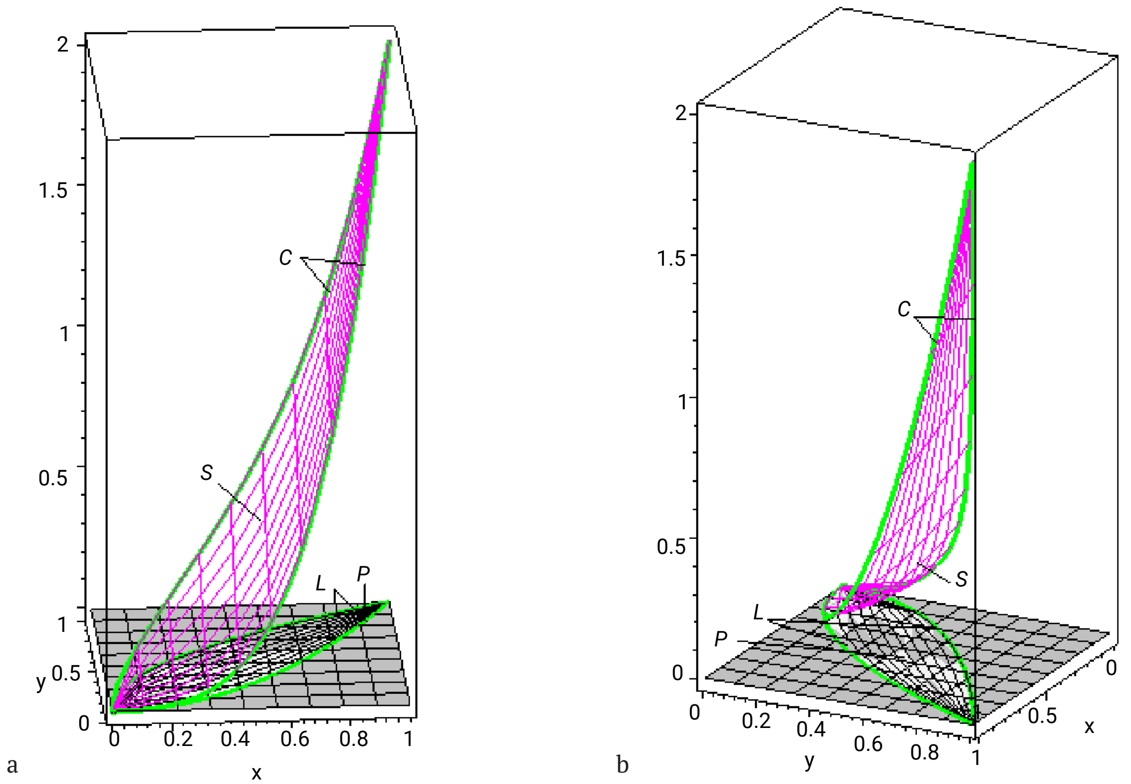


Figure 6. Visualisation of the constructed elements of the cylindrical body: the coordinate plane *Oxy*, region *P* together with its boundary L, and the portion of surface S bounded by the closed contour *C*

Note: a – `orientation = [-94, 70]`;b – `orientation = [27, 70]`

Source: compiled by the authors

In the sixth step, the cylindrical surface *Q* was constructed. Based on the general equations (2) of the family of generatrices in the case under consideration, the following was obtained:

$$\begin{cases} x = t_i, \\ y = \sqrt{t_i}, \\ z = (t_i{}^4 + t_i) \cdot t, \end{cases} \quad t \in [0.1]. \qquad \begin{cases} x = t_i, \\ y = t_i{}^2, \\ z = 2t_i{}^4 \cdot t, \end{cases} \quad t \in [0.1]. \quad (5)$$

Consequently, the program code took the form of:

```
numLines := 25:
for i from 0 to numLines do
t :=(i/numLines)*1;
lines1[i]:=plottools[line]([t,sqrt(t),0],
[t,sqrt(t),t^4+t], color=blue, linestyle=1,
thickness=1);
end do:t:='t':

for i from 0 to numLines do
t :=(i/numLines)*1;
lines2[i]:=plottools[line]([t,t^2.0],
[t,t^2,2*t^4], color=blue, linestyle=1,
thickness=1);
end do:t:='t':
```

The application of the plottools[line] command made it possible to implement the element-by-element visualisation of the cylindrical surface as a collection of generators, corresponding to the geometric nature of this object and enhancing the clarity of its spatial representation. An important advantage of this approach was the possibility of forming a visually transparent lateral surface, the degree of transparency of which was controlled by the value of the variable numLines, thereby ensuring clear perception of the internal structure of the model and the mutual arrangement of its elements. Figure 7 presents the graph of the cylindrical surface constructed by the described method together with its lower and upper guide curves. The corresponding fragment of the program code is given below.

```
plots[display]( {seq(lines1[i], i=1..numLines),
seq(lines2[i], i=1..numLines), GuideCS,GuideCC},
axes=boxed, scaling=unconstrained,
orientation=[157,56]); surfaceQ:=%:
```

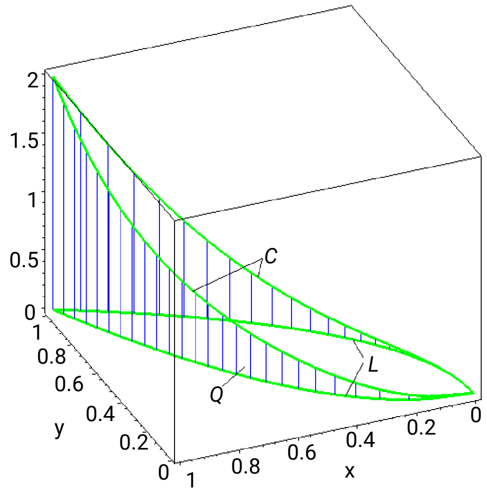


Figure 7. Construction of the cylindrical surface *Q* together with its lower and upper guide curves
Source: compiled by the authors

Upon completion of the construction, a graphical representation of the cylindrical body was visualised, showing all the generated elements (Fig. 8). The figure consists of four three-dimensional images obtained for different values of the orientation parameter, providing a more comprehensive view of the object's geometry. This made it possible to trace in detail the relative positions of the surfaces, generatrices and generatrixes, and to confirm the correctness of their construction.

```
plots[display]([PlaneOXY, GuideCS,
zeroP, GuideCC, surfaceSc, surfaceQ],
orientation=[-174,69]);
```

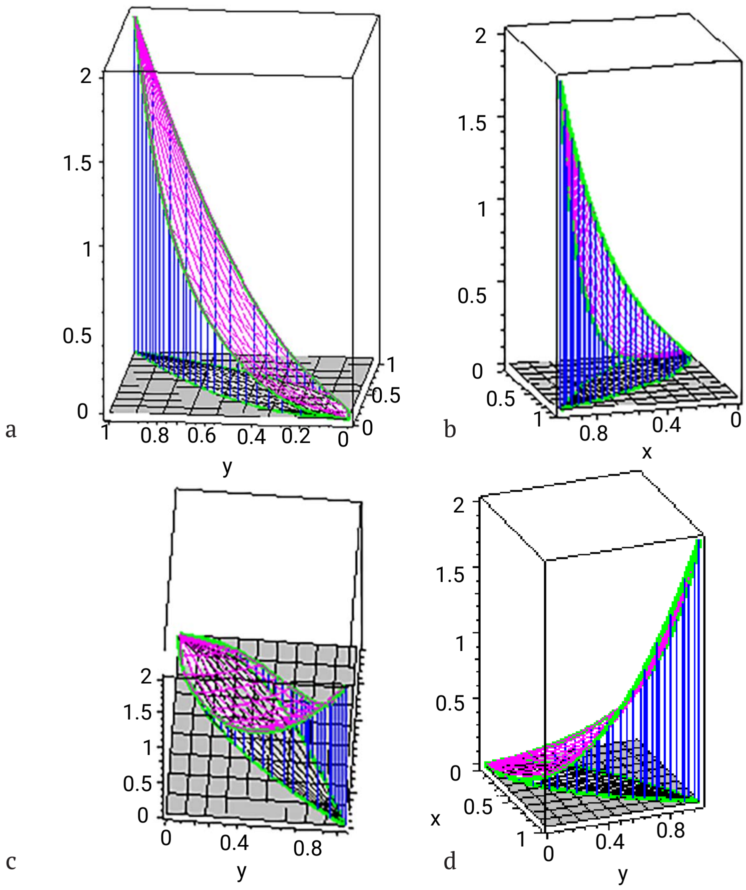


Figure 8. Three-dimensional representation of the cylindrical body with all structural elements in the Maple system
Note: viewing angles: a – `orientation = [-174, 69]`; b – `orientation = [70,73]`; c – `orientation = [4,21]`; d – `orientation = [-22,63]`
Source: compiled by the authors

Thus, in the study the `plots[display]` command was used to combine all the elements of the structured mathematical model of a cylindrical body – the projection plane, guidelines, generating lines, boundary surfaces and spatial intersection lines – into a single, consistent three-dimensional image. This ensured: the correct relative positioning of elements in space; uniform scaling of all components; the ability to set a common viewing angle (`the orientation` parameter); and consistent display of coordinate axes and style parameters.

Following a detailed examination of the proposed method for constructing a 3D visualisation of a cylindrical body using a specific example, with the aim of demonstrating the universality of the proposed approach and confirming its effectiveness in solving typical applied problems, the application of the developed techniques to problems encountered in various textbooks was considered. The problems were selected to demonstrate the possibility of using various analytical expressions to describe cylindrical bodies.

First of all, the problem of calculating a double integral was considered $\int_0^1 dx \int_0^{x^2} x^2 + y^2 dy$ (Sachaniuk-Kavetska *et al.*, 2013). The notation of the double integral – specifically in the form of the integrand and the limits of integration for the inner and outer integrals – contains all the necessary relationships for describing a cylindrical solid, as shown in the captions to Figure 9, which depicts the corresponding solid, the volume of which is calculated by this integral. In the example given, the general relations were adapted to describe the domain of the function, which is bounded not by two but by three analytically defined lines.

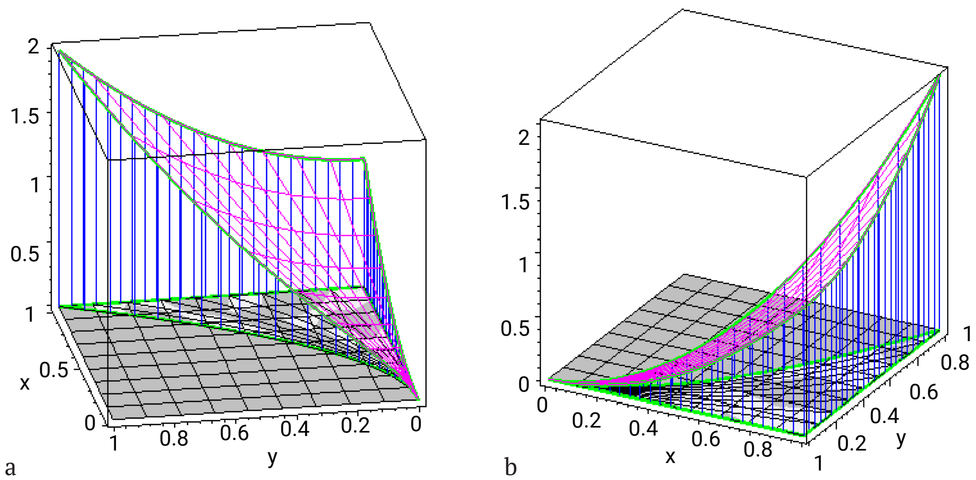


Figure 9. Cylindrical body bounded by the surfaces: z=0 and z=x2+y2, as well as by the guide curves y=0, y=x2, x=1, lying in the Oxy plane; $x \in [0; 1]$

Note: a – `orientation = [155,67]`; b – `orientation = [-62,68]`

Source: compiled by the authors

The approach presented here has been applied to solve the problem of computing a double integral $\iint_D \sqrt{x^2+y^2}\,dxdy$ (Zhuravska *et al.*, 2015), where the region D is bounded by the lines $x^2+y^2=2x$, $x^2+y^2=4x$. By converting to polar coordinates p, φ, related to the Cartesian coordinates x and y by the relations: $x = p\cos(\varphi)$, $y = p\sin(\varphi)$, the problem is reduced to the calculation of a double integral $\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} d\varphi \int_{2\cos(\varphi)}^{4\cos(\varphi)} \rho^2 d\rho$. The conversion to polar coordinates allows for a significant simplification of the calculation for circular or radial regions, as the limits of the integrals take on a simpler form. Figure 10 shows the corresponding cylindrical solid, the volume of which is calculated by this integral.

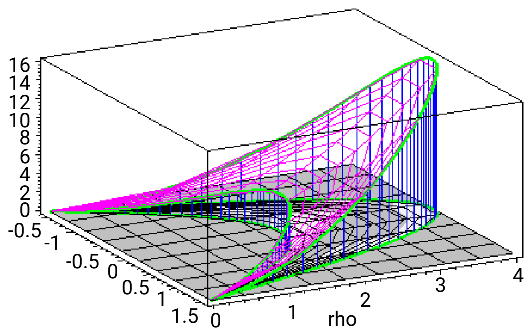


Figure 10. Cylindrical body bounded by the surfaces $z=0$, $z=p^2$ and the guide curves $p=2\cos(\varphi)$, $p=4\cos(\varphi)$, $\varphi \in \left[-\frac{\pi}{2}; \frac{\pi}{2}\right]$

Source: compiled by the authors

The proposed method was also effective in solving the more complex problem of computing the double integral $\iint_D (2x+1)\cdot\frac{sin(\pi(x+y))}{cos^3(\pi(x+y))}dxdy$ (Veryhina & Massalitina, 2016), where the region D is bounded by the lines $y=-x, y=x^2+\frac{1}{4}, x=0$. The complexity of the problem stems from the need to compute integrals over more complex domains and to account for complex constraints, which require a more detailed spatial analysis. Figure 11 shows the corresponding cylindrical body in the form of four three-dimensional images presented from different viewing angles, providing a comprehensive view of its spatial structure and the relative positioning of the boundary elements. The use of several different viewing angles allows for a more accurate assessment of the spatial relationships and the complexity of the cylindrical body's geometric shape.

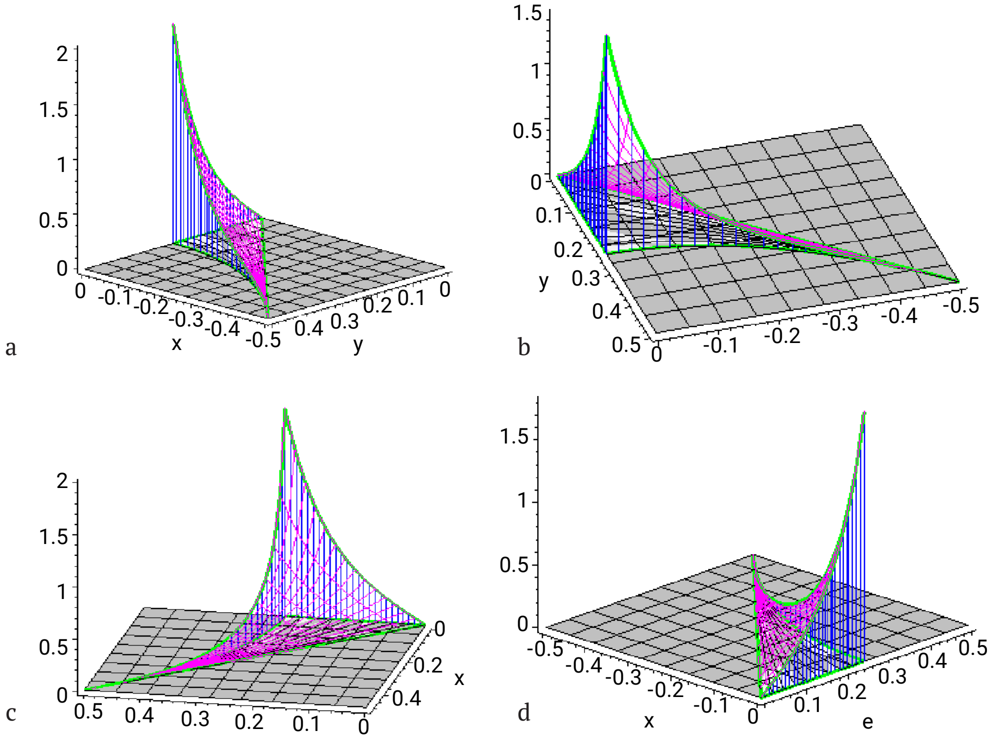


Figure 11. Cylindrical body bounded by the surfaces: $z=0$, $z=(2x+1)\cdot\frac{sin(\pi(x+y))}{cos^3(\pi(x+y))}$ and the guide curves $y=-x$, $y=x^2+\frac{1}{4}$, $x=0$
Note: viewing angles: a – `orientation = [134, 72]`; b – `orientation = [72, 53]`; c – `orientation = [-66, 68]`; d – `orientation = [-46, 68]`
Source: compiled by the authors

The presented examples illustrated the universality and flexibility of the proposed method for the three-dimensional visualisation of cylindrical bodies in the Maple environment. This methodology may be successfully adapted for the graphical representation of a wide range of educational and applied problems encountered in academic and engineering practice. The developed approach makes it possible to achieve a high degree of accuracy and clarity in solving problems requiring three-dimensional visualisation and significantly simplifies the process of modelling complex geometric bodies. This makes the method a useful tool for solving both theoretical and practical problems in scientific research and engineering calculations.

In contemporary scientific research, three-dimensional visualisation of surfaces using specialised software tools is regarded as an effective instrument for analysing complex mathematical models and applied problems. In particular, the `plot3d` command and analogous tools in other software packages are widely employed in various fields of science and technology for the visual representation of computational and modelling results. In this context, it is appropriate to compare the results of the present study with corresponding approaches presented in contemporary scientific works.

Thus, in the study by F. Septian (2024), three-dimensional visualisation is used for analysing the Rosenbrock function, employed as a test function in optimisation algorithms for modelling the social behaviour of humpback whales. In that work, the primary focus was placed on interpreting the behaviour of optimisation algorithms through graphical analysis of the function surface, whereas the issue of the structural organisation of the geometric model itself was not considered. In contrast, in the present study visualisation was regarded not merely as a means of presenting results, but as an object of methodological development involving the step-by-step construction of individual components of the spatial model.

A similar nature of applying three-dimensional graphs can be observed in the work of D. Lenoci *et al.* (2022), where visualisation was employed to present the results of statistical processing of medical data. In this case, graphical tools performed mainly an illustrative function, whereas the algorithmic aspects of constructing complex geometric objects were not analysed. In the present work, by contrast, attention is focused on the software implementation of a structured mathematical model of a spatial body and the possibility of controlling the mutual arrangement of its elements during construction. In the studies of K. Apriandy *et al.* (2023a; 2023b), the three-dimensional visualisation functions of the MATLAB environment were applied to the kinematic modelling of the humanoid robotic arm T-FloW. Compared with this approach, in which visualisation played an auxiliary role in modelling a mechanical system, the present work develops a method oriented directly towards the formation of the three-dimensional geometric structure of an object through element-by-element construction.

In the work of M.A. Mohammed *et al.* (2022), an integrated method for selecting an optimal deep-learning model based on a novel "crow swarm" optimisation algorithm for COVID-19 diagnosis was proposed; however, the absence of clear images of the presented analytical surface representations somewhat reduces the practical and theoretical value of the proposed solutions. W.W. Mohammed (2022) and M. Bilal *et al.* (2022) employed three-dimensional surfaces for the visual representation of analytical solutions and for studying the influence of parameters on their behaviour. Similar to these studies, visualisation contributes to the interpretation of results; however, unlike them, the present research places particular emphasis on the methodological aspects of forming the geometric model itself and on the possibility of its adaptive parameterisation.

In the study by Z. Guo *et al.* (2023), the plot3d function was applied to evaluate the residual strength of materials; in this case, as in most applied studies, three-dimensional graphs primarily performed the function of visualising the results of experimental or numerical analysis. In contrast, the present work considered the process of constructing a spatial object as an independent task requiring formalisation, algorithmisation, and step-by-step software implementation. A similar nature of the use of three-dimensional surfaces can also be observed in the studies of A.I. Chowdhury *et al*. (2025) and Y. Lou *et al.* (2022), where surfaces of limiting plastic deformations were visualised as functions of two dimensionless stress-state indicators according to the Tresca–Ressayre and related models. In these works, characteristic curves were highlighted on the surfaces, which may indicate the combined use of tools such as `plot3d` and `spacecurve`; however, the issue of the element-by-element visualisation of all components of a cylindrical body was not considered.

Particularly close in direction is the study by T. Dana-Picard (2023), in which a combination of the `plot3d` and `spacecurve`. commands was used for visualising the surfaces of channels and pipes. Similar to this approach, the present work employs a combination of graphical tools to distinguish individual geometric elements. At the same time, the proposed method differs in its systematic nature of construction and its orientation towards structuring the mathematical model of the spatial object. Similar capabilities of Maple as a universal tool for numerical and symbolic analysis, as well as three-dimensional visualisation, were demonstrated in the work of N. Sawlat *et al.* (2024), where the effectiveness of the software package in solving a wide range of applied problems was shown and its potential for creating complex three-dimensional graphs was emphasised.

At the same time, the development of Maple through the creation of user-defined software solutions and specialised procedures remains at the centre of contemporary research attention, confirming the relevance of developing applied algorithms for the visualisation of particular classes of geometric objects. Nevertheless, in the aforementioned works, three-dimensional visualisation is considered predominantly as an auxiliary means of presenting computational results, without emphasis on the step-by-step construction of geometric objects. Thus, comparison with contemporary studies demonstrates that in most works three-dimensional visualisation is used mainly as a means of illustrating modelling results, whereas in the present study it is regarded as an independent object of methodological and software development.

Conclusions

This article proposes a method for the three-dimensional visualisation of cylindrical solids in the Maple computer algebra system, based on breaking down the mathematical model of the solid into individual components and constructing each of them step by step using specialised graphical tools. A system of methods and techniques for software implementation has been developed, involving the parameterisation of guide curves, the construction of generating segments, the formation of projections onto the *Oxy* plane, and the graphical combination of all elements into a coherent 3D model. It is shown that the proposed approach is independent of the specific analytical form of the cylindrical body and can be adapted to problems with different geometric conditions, as confirmed by examples from textbooks.

It has been established that the absence in Maple of standard tools for the automated construction of cylindrical bodies necessitates the development of specialised software solutions; the proposed method can serve as a basis for creating user procedures and be regarded as a component of information technology for the three-dimensional visualisation of geometric objects. This interpretation is based on the generally accepted understanding of information technology as a set of methods, algorithms and software tools designed for the processing, presentation and analysis of information. The proposed approach meets these criteria, as it involves the algorithmic processing of mathematical information about a geometric object, its software implementation and graphical interpretation in the form of three-dimensional models. The proposed approach facilitates the perception of complex spatial objects, stimulates analytical thinking and develops applied competencies in the field of mathematical modelling; its application is effective not only in the educational process but also in scientific research and engineering practice, where visualisation plays a key role in solving problems of geometric analysis, form optimisation and the study of spatial relationships.

The results obtained can serve as a basis for further research, in particular for the development of automated visualisation procedures for cylindrical bodies. Furthermore, these results can be generalised to cases involving more complex geometric configurations, where the body is bounded from below by an arbitrary surface and the domain of definition is specified by a system of several analytical relations. It is expected that further research will significantly improve computational efficiency and expand the scope of application of this methodology to more complex engineering and scientific problems, particularly in the field of optimisation and modelling of non-standard geometric structures.

Acknowledgements

None.

Funding

The study received no funding.

Conflict of Interest

None.

References

[1] Apriandy, K.I., Dewantara, B.S.B., Dewanto, R.S., & Pramadihanto, D. (2023a). Advanced kinematics analysis of the 4-fingered robotic hand used in the T-FLoW humanoid robot. *The Indonesian Journal of Computer Science*, 12(4), 1901-1915. doi: 10.33022/ijcs.v12i4.3291.

[2] Apriandy, K.I., Dewantara, B.S.B., Dewanto, R.S., Pramadihanto, D., & Ryando, C. (2023b). Design and experiment of a four-fingered robotic hand for T-FLoW 4.0 humanoid robot. In *2023 international electronics symposium (IES)* (pp. 354-359). Denpasar: IEEE. doi: 10.1109/IES59143.2023.10242443.

[3] Bilal, M., Younis, M., Shafqat-Ur-Rehman, Ahmad, J., & Younas, U. (2022). Investigation of new solitons and other solutions to the modified nonlinear Schrödinger equation in ocean engineering. *Journal of Ocean Engineering and Science*. doi: 10.1016/j.joes.2022.04.031.

[4] Chelombitko, V.F. (2024). Additional means of enhancing the protection of securities forms. In O.V. Vovk, I.B. Chebotariova & Zh.V. Deineko (Eds.), *Printing, multimedia and web technologies: Innovations and development* (pp. 107-123). Kharkiv: Madrid Printing House LLC. doi: 10.30837/978-617-7988-99-0.

[5] Chelombitko, V.F., & Tkachenko, V.P. (2022). Methods for constructing geometric ornaments for the protection of securities. In O.V. Vovk, I.B. Chebotarova & Zh.V. Deineko (Eds.), *Printing, multimedia and web technologies: Innovations* (pp. 115-144). Kharkiv: Kharkiv National University of Radioelectronics. doi: 10.30837/978-617-7988-99-0.

[6] Chowdhury, A.I., Alhalaybeh, T.S., Zhou, L., Liang, X., & Lou, Y. (2025). Inverse engineering based analytical and numerical prediction on ductile fracture for AZ60M magnesium alloy under wide stress triaxiality. *Engineering Fracture Mechanics*, 326, article number 111384. doi: 10.1016/j.engfracmech.2025.111384.

[7] Dana-Picard, T. (2023). Exploration of envelopes of parameterized families of surfaces in a technology-rich environment. *Electronic Journal of Mathematics & Technology*, 17(2).

[8] Espejo-Peña, D.A., & Flores-Osorio, A.I. (2023). Modeling bounded surfaces using cylindrical coordinates using GeoGebra AR. In L.-Y. Cheng (Ed.), *ICGG 2022 – proceedings of the 20th international conference on geometry and graphics. Lecture notes on data engineering and communications technologies* (Vol. 146; pp. 870-879). Cham: Springer. doi: 10.1007/978-3-031-13588-0_76.

[9] Guo, Z., Ma, C., Liu, Y., Li, F., & Li, C. (2023). Residual strength prediction and structural response of a multi-chamber cabin to a fire. *Journal of Marine Engineering & Technology*, 22(6), 294-303. doi: 10.1080/20464177.2023.2233264.

[10] Ipanaqué-Chero, R., Urbina-Guzmán, R.T., & Velezmoro-León, R. (2025). BSplineSolid: Symbolic construction and visualization of rational trivariate solids in Mathematica. *SoftwareX*, 31, article number 102305. doi: 10.1016/j.softx.2025.102305.

[11] Kusno, A.R. (2022). Learning materials development of parametric curves and surfaces for modeling the objects using Maple on differential geometry courses. In *Proceedings of the international conference on mathematics, geometry, statistics, and computation (IC-MaGeStiC 2021)* (pp. 125-132). Dordrecht: Atlantis Press. doi: 10.2991/acsr.k.220202.025.

[12] Lavicza, Z., Abar, C.A.P., & Tejera, M. (2023). Spatial geometric thinking and its articulation with the visualization and manipulation of objects in 3D. *Educação Matemática Pesquisa Revista Do Programa de Estudos Pós-Graduados Em Educação Matemática*, 25(2), 258-277. doi: 10.23925/1983-3156.2023v25i2p258-277.

[13] Lenoci, D., Carenzo, A., Cavalieri, S., Pistore, F., Serafini, M.S., Bossi, P., Schmitz, S., Machiels, J.-P., Licitra, L.F., & De Cecco, L. (2022). Biological properties of hypoxia-related gene expression models/signatures on clinical benefit of anti-EGFR treatment in two head and neck cancer window-of-opportunity trials. *Oral Oncology*, 126, article number 105756. doi: 10.1016/j.oraloncology.2022.105756.

[14] Lieban, D., & Bueno, R.W. (2022). An exploratory modelling task by slicing 3D shapes: The Three Worlds of Mathematics through an historical and technological approach. In *Twelfth congress of the european society for research in mathematics education (CERME12)* (article number hal-03759042). Bozen-Bolzano: HAL Open Science.

[15] Liu, X., Jia, J., & Liu, C. (2023). Survey of lightweighting methods of huge 3D models for online Web3D visualization. *Virtual Reality & Intelligent Hardware*, 5(5), 395-406. doi: 10.1016/j.vrih.2020.02.002.

[16] Lou, Y., Wu, P., Zhang, C., Wang, J., Li, X., Chai, R., & Yoon, J.W. (2022). A stress-based shear fracture criterion considering the effect of stress triaxiality and Lode parameter. *International Journal of Solids and Structures*, 256, article number 111993. doi: 10.1016/j.ijsolstr.2022.111993.

[17] Mohammed, M.A., Al-Khateeb, B., Yousif, M., Mostafa, S.A., Kadry, S., Abdulkareem, K.H., & Garcia-Zapirain, B. (2022). Novel crow swarm optimization algorithm and selection approach for optimal deep learning COVID-19 diagnostic model. *Computational Intelligence and Neuroscience*, 2022(1), article number 1307944. doi: 10.1155/2022/1307944.

[18] Mohammed, W.W., Iqbal, N., Albalahi, A.M., Abouelregal, A.E., Atta, D., Ahmad, H., & El-Morshedy, M. (2022). Brownian motion effects on analytical solutions of a fractional-space long-short-wave interaction with conformable derivative. *Results in Physics*, 35, article number 105371. doi: 10.1016/j.rinp.2022.105371.

[19] Mykhalevych, V., Dobraniuk, Y., Matviichuk, V., Kraievskyi, V., Tiutiunnyk, O., Smailova, S., & Kozbakova, A. (2023). A comparative study of various models of equivalent plastic strain to fracture. *Informatyka, Automatyka, Pomiary w Gospodarce i Ochronie Środowiska*, 13(1), 64-70. doi: 10.35784/iapgos.3496.

[20] Sachaniuk-Kavetska, N.V., Kraievskyi, V.O., Kovalchuk, M.B., & Chernovolyk, H.O. (2013). *Higher mathematics with computer support: Functions of several variables and multiple integrals*. Vinnytsia: VNTU.

[21] Sawlat, N., Qani, Y., & Sadeqi, N. (2024). Numerical and symbolic analysis for mathematical problem-solving with Maple. *Journal of Natural Science Review*, 2(3), 29-46. doi: 10.62810/jnsr.v2i3.75.

[22] Septian, F. (2024). Exploring the performance of whale optimization algorithm on Rosenbrock's function. *Journal of Intelligent Systems and Information Technology*, 1(2), 47-56. doi: 10.61971/jisit.v1i2.35.

[23] Serdiuk, O.V., Sukhorukov, S.I., Serdiuk, V.V., & Korchynskyi, O.A. (2021). Investigation of the rolling process with a roller having a helical working surface. *Herald of Khmelnytskyi National University. Technical Sciences*, 5, 66-68.

[24] Turzhanska, O.S. (2023). Computer algebra systems as components of the educational environment in teaching mathematical disciplines. In M.M. Kovtoniuk & S.M. Baka (Eds.), *Problems of mathematics and informatics in teacher education institutions: Theory and practice* (Pt. 2; pp. 131-151). Vinnytsia: VSPU.

[25] Veryhina, I.V., & Massalitina, Ye.V. (2016). *Multiple integrals: A practical course in higher mathematics for students of the thermal engineering faculty (full-time and part-time study)*. Kyiv: NTUU "KPI".

[26] Zhuravska, H.V., Kopas, I.M., Kulyk, H.M., Reva, N.V., & Stepanenko, N.V. (2015). *Methodical guidelines and sets of calculation assignments: Multiple integrals*. Kyiv: NTUU "KPI".

3D візуалізація циліндричних тіл у СКМ Maple: оригінальні прийоми та техніки

Володимир Михалевич
Доктор технічних наук, професор
Вінницький національний технічний університет
21021, вул. Хмельницьке шосе, 95, м. Вінниця, Україна
https://orcid.org/0000-0003-1557-7331

Оксана Тютюнник
Кандидат педагогічних наук, доцент
Вінницький національний технічний університет
21021, вул. Хмельницьке шосе, 95, м. Вінниця, Україна
https://orcid.org/0000-0002-8544-4246

Юрій Добранюк
Кандидат технічних наук, доцент
Вінницький національний технічний університет
21021, вул. Хмельницьке шосе, 95, м. Вінниця, Україна
https://orcid.org/0000-0001-6387-6331

Майя Ковальчук
Доктор технічних наук, професор
Вінницький національний технічний університет
21021, вул. Хмельницьке шосе, 95, м. Вінниця, Україна
https://orcid.org/0000-0002-1895-1715

Анотація. Актуальність теми зумовлена зростанням потреби у використанні сучасних засобів комп'ютерної математики для підвищення ефективності аналізу, моделювання та візуалізації складних просторових об'єктів. Метою роботи була розробка оригінального способу тривимірної візуалізації циліндричних тіл у системі комп'ютерної математики Maple. Запропонований підхід базувався на структуризації математичної моделі циліндричного тіла на окремі елементи – площину проєкції, напрямні криві, твірні відрізки та обмежувальні поверхні – з подальшою їх інтеграцією у єдину 3D-модель. У дослідженні використано базові інструменти Maple (`plot3d`, `spacecurve`, `plottools[line]`, `display`), що забезпечили програмну реалізацію окремих елементів просторового об'єкта та їх поетапне поєднання в цілісну модель циліндричного тіла з метою створення наочного тривимірного зображення. Розроблено низку оригінальних технік побудови плоских та просторових напрямних, заданих парою кривих, що перетинаються та утворюють замкнену область, сім'ї твірних у вигляді відрізків прямих для утворення прозорої бічної циліндричної поверхні, а також способів візуалізації поверхонь, які дозволяють адаптивно змінювати параметри моделі, відображати проміжні етапи побудови та контролювати взаємне розташування її елементів. Представлено приклади практичної реалізації способу для побудови циліндричних тіл на основі типових задач з вищої математики, що підтверджує ефективність і зручність застосування розробленого підходу. Показано, що запропонований спосіб має універсальний характер і може бути використаний не лише у навчальному процесі, а й у наукових дослідженнях і прикладних інженерних задачах, де потрібна точна й наочна 3D-візуалізація багатокомпонентних тіл. Практична цінність роботи полягає в тому, що розроблений підхід може розглядатися як складова інформаційної технології тривимірної візуалізації геометричних об'єктів у системах комп'ютерної математики, поєднуючи простоту реалізації, гнучкість моделювання та високу інформативність графічних результатів

Ключові слова: системи комп'ютерної математики; параметричні криві та поверхні; геометричне моделювання; освітні технології в математиці; прикладне математичне моделювання; інженерна візуалізація