

Отчёт по лабораторной работе №8

Diagrams and Drawings as Code

ДРАММЕХ МАРИАМА Л

Содержание

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1 Цель работы

Целью данной лабораторной работы является освоение создания диаграмм и рисунков программным способом в LaTeX с использованием пакета TikZ и других инструментов для визуального представления данных и математических объектов.

The purpose of this lab work is to learn how to create diagrams and drawings programmatically in LaTeX using the TikZ package and other tools for visual representation of data and mathematical objects.

2 Задание

1. Изучить основы создания графики с помощью пакета TikZ
2. Освоить построение линий, кривых и узлов в TikZ
3. Научиться создавать сложные графики и диаграммы
4. Изучить построение фракталов и рекурсивных структур
5. Выполнить практические упражнения по созданию графиков и фракталов
6. Создать график функций и ковёр Серпинского

3 Теоретическое введение

3.1 8 Диаграммы и рисунки как код / Diagrams and Drawings as Code

3.1.1 8.1 TikZ

TikZ - это мощный пакет для создания графики программным способом в LaTeX. Название является рекурсивным акронимом "TikZ ist kein Zeichenprogramm" (TikZ - это не программа для рисования).

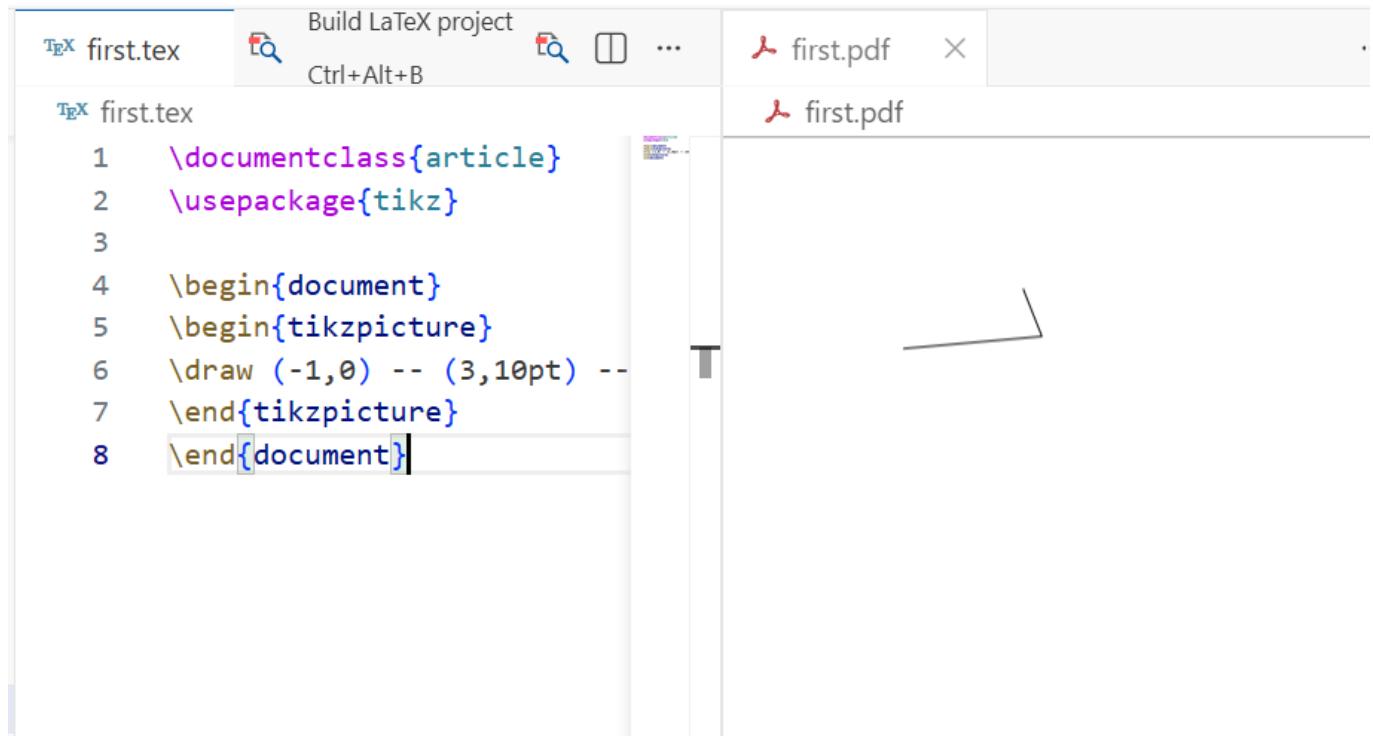
TikZ is a powerful package for creating graphics programmatically in LaTeX. The name is a recursive acronym "TikZ ist kein Zeichenprogramm" (TikZ is not a drawing program).

```
\documentclass{article}
```

```
\usepackage{tikz}
```

```
\begin{document}
```

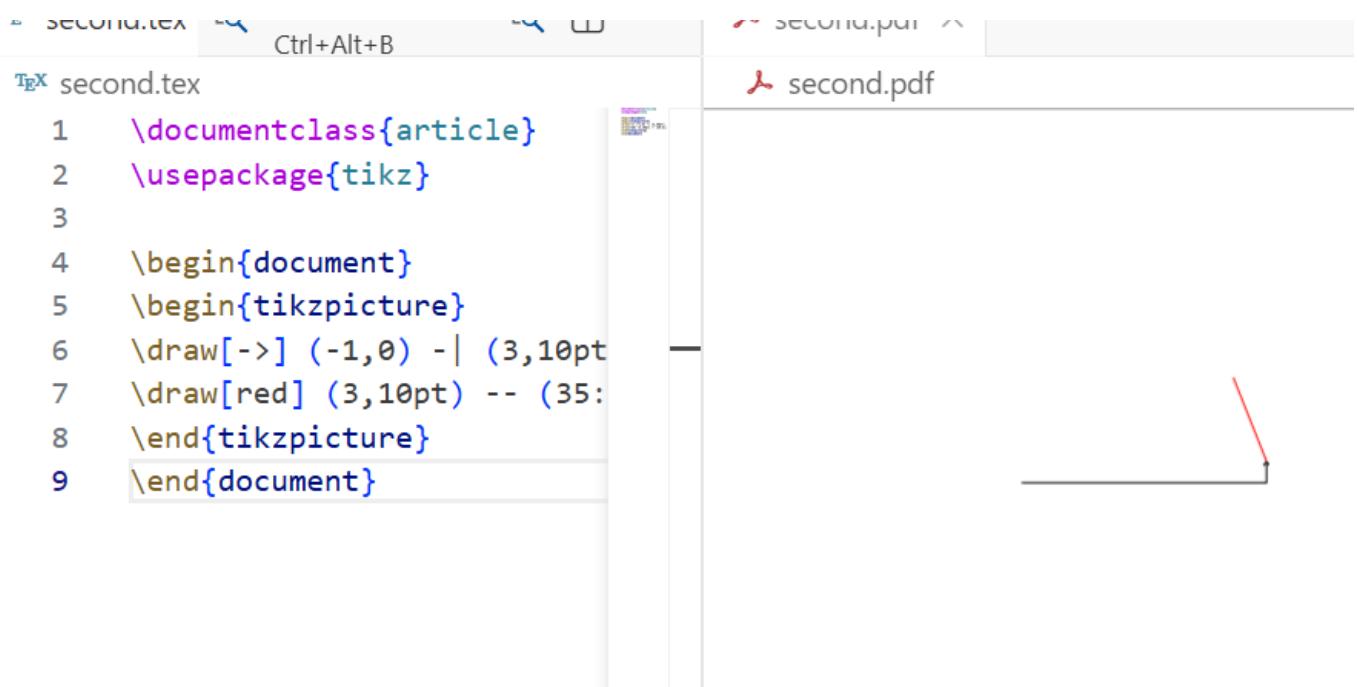
```
\begin{tikzpicture}
\draw (-1,0) -- (3,10pt) -- (35:3);
\end{tikzpicture}
\end{document}
```



3.1.2 8.1.1 Строительные блоки TikZ / Building Blocks of TikZ

Для создания рисунков в TikZ необходимо загрузить пакет tikz и использовать окружение tikzpicture. To create figures in TikZ you need to load the tikz package and use the tikzpicture environment.

```
\documentclass{article}
\usepackage{tikz}
\begin{document}
\begin{tikzpicture}
\draw[->] (-1,0) -| (3,10pt);
\draw[red] (3,10pt) -- (35:3);
\end{tikzpicture}
\end{document}
```



```
\documentclass{article}
\usepackage{tikz}

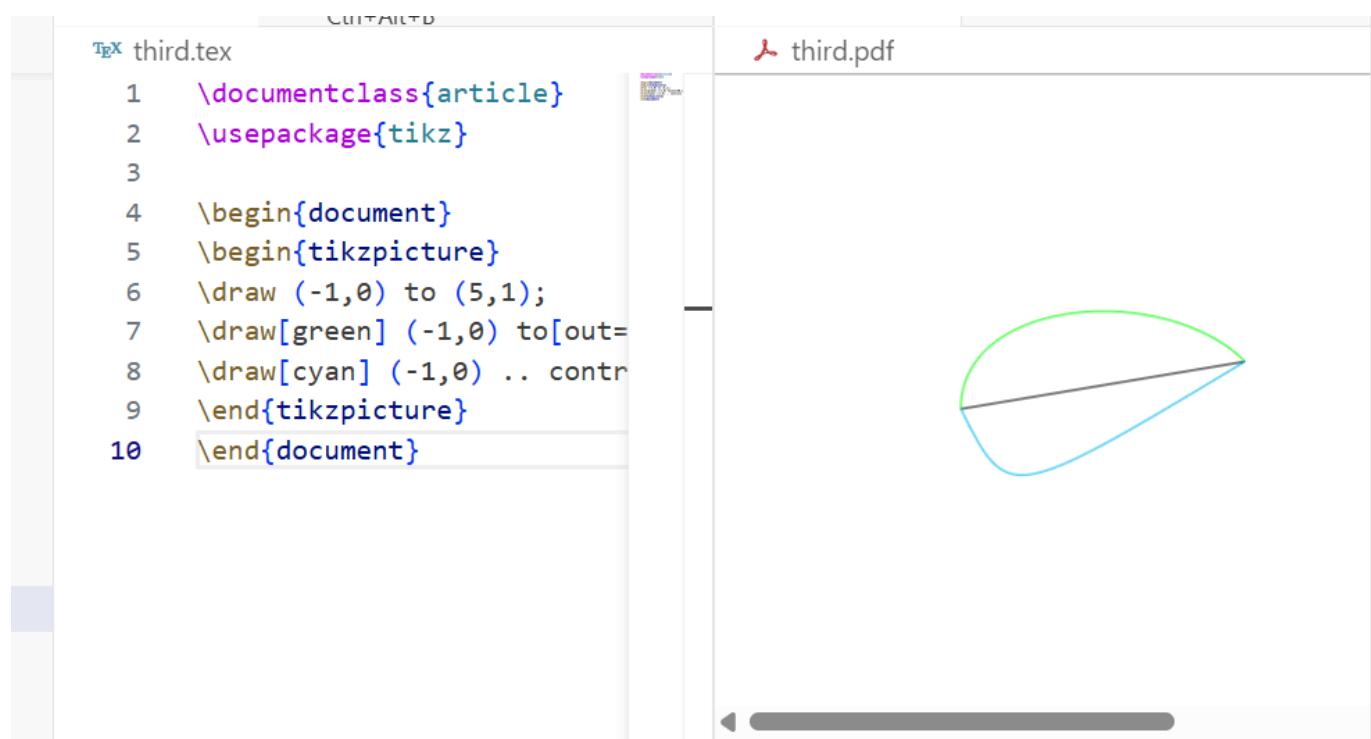
\begin{document}
\begin{tikzpicture}
\draw[->] (-1,0) -| (3,10pt);
\draw[red] (3,10pt) -- (35:5);
\end{tikzpicture}
\end{document}
```

3.1.3 8.1.2 Рисование линий / Drawing Lines

TikZ предоставляет различные типы линий и стили оформления. TikZ provides various types of lines and styling options.

```
\documentclass{article}
\usepackage{tikz}

\begin{document}
\begin{tikzpicture}
\draw (-1,0) to (5,1);
\draw[green] (-1,0) to[out=90,in=135] (5,1);
\draw[cyan] (-1,0) .. controls (0,-2) .. (5,1);
\end{tikzpicture}
\end{document}
```



The screenshot shows a LaTeX editor interface with two panes. The left pane, titled 'third.tex', contains the following LaTeX code:

```
\documentclass{article}
\usepackage{tikz}

\begin{document}
\begin{tikzpicture}
\draw (-1,0) to (5,1);
\draw[green] (-1,0) to[out=90,in=135] (5,1);
\draw[cyan] (-1,0) .. controls (0,1) and (2,1) .. (5,1);
\end{tikzpicture}
\end{document}
```

The right pane, titled 'third.pdf', displays the resulting PDF document. It features a green circle centered at the origin. A black straight line segment (diameter) connects the points (-1,0) and (5,1). A cyan curved arc is drawn from (-1,0) to (5,1), starting at 90 degrees and ending at 135 degrees. A blue curved arc is also present, connecting (-1,0) to (5,1) via a control point at (2,1).

3.1.4 8.1.3 Узлы / Nodes

Узлы используются для добавления текста и меток в рисунки. Nodes are used to add text and labels to drawings.

```
\documentclass{article}

\usepackage{tikz}

\begin{document}
\begin{tikzpicture} [scale=2]

% Define the nodes
\node[circle, draw] at (0,0) (a) {A};
\node[rectangle, fill] at (3,0) (b) {};
\node at (3,0.4) (blabel) {B};
\node[rectangle,rounded corners, draw] at (5,2) (c) {C};

% Draw the paths
\draw[->, green] (a) -- (b) node[midway, below,black]{2};
\draw[<->, blue] (a) to[out=45, in=135] (b);
\draw[->,red] (b)--(c);
\draw[yellow,dotted,very thick] (b) |- (c);
\draw[<-,cyan] (b) -| (c);

\end{tikzpicture}
\end{document}
```

```
\draw[thick,black] (a).. controls (1,5) .. (c) node[midway,
above]{$\frac{1}{2}$}; \end{tikzpicture}
\end{document}
```

The screenshot shows a LaTeX editor with two panes. The left pane contains the TeX code for 'nine.tex', which includes document class, package imports, and a tikzpicture environment with various nodes and paths. The right pane shows the generated PDF 'nine.pdf', which displays a mathematical diagram with a black curve, a blue curve, and a red line segment. The axes are labeled with 2 and $\frac{1}{2}$. A dotted yellow square highlights the rightmost part of the graph.

3.1.5 8.1.4 Построение графиков / Plotting Curves

TikZ позволяет строить графики функций напрямую. TikZ allows plotting function curves directly.

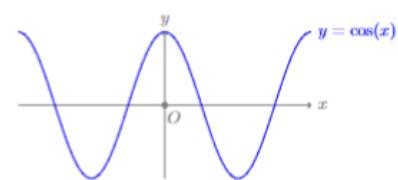
```
\documentclass{article}
\usepackage{tikz}
\begin{document}
\begin{tikzpicture} [scale=1.5]
% Draw the x and y axis, label the axes and the origin
\draw[gray, ->] (-2,0) -- (2,0) node[right]{$x$};
node[pos=0.53, below]{$O$};
\draw[gray, ->] (0,-1) -- (0,1) node[above]{$y$};
\draw[fill,gray] (0,0) circle [radius=1pt];
% Plot the curve
% Note: the r in the argument of the cosine signifies that we enter \x in radians
\draw[thick,black] (0,0) .. controls (0.5,0.5) and (1,1) .. (2,0);
\draw[blue,thick] (0,0) .. controls (0.5,0.1) and (1,0.2) .. (2,0);
\draw[red,thick] (0,0) -- (2,0);
\end{tikzpicture}
```

```
\draw[blue, thick] [domain=-2:2, samples=150] plot (\x,
{\cos(pi*\x r)})
node[right]{$y = \cos(x)$};
\end{tikzpicture}
\end{document}
```

TeX elev.tex

```
1  \documentclass{article}
2  \usepackage{tikz}
3
4  \begin{document}
5  \begin{tikzpicture} [scale=
6  % Draw the x and y axis, la
7  \draw[gray, ->] (-2,0) -- (
8  node[pos=0.53, below]{$O$};
9  \draw[gray, ->] (0,-1) -- (
10 \draw[fill,gray] (0,0) circ
11 % Plot the curve
12 % Note: the r in the argume
13 \draw[blue, thick] [domain=
14 {\cos(pi*\x r)})
15 node[right]{$y = \cos(x)$};
16 \end{tikzpicture}
17 \end{document}
```

elev.pdf



3.1.6 8.1.5 Работа с циклами / Working with Loops

Циклы `\foreach` позволяют создавать сложные рисунки эффективно. `\foreach` loops allow creating complex drawings efficiently.

```
\documentclass[tikz,border=1cm]{standalone}

\usepackage{tikz}

\usetikzlibrary{math}

% Define a equilateral triangle with lower left corner at
% coordinate #1 and with length of the sides #2

\newcommand\Triangle[2]{

\draw #1 coordinate(a) -- ++(0:#2) coordinate(b) ;
\draw (a) -- ++(60:#2) coordinate(c);
\fill (a) -- (b) -- (c) -- cycle;

}
```

```
\begin{document}

\begin{tikzpicture}

\tikzmath{

% Define the recursive function sierpinski

function sierpinski(\x, \y, \s, \d) {

if (\d == 0) then {

% Draw a triangle lower left corner at (\x, \y), length \s

{ \Triangle{(\x,\y)}{\s}; };

} else {

% Rescale the length of the sides and choose correct coords

% for the next triangles

\u1 = 0.25*\s;

\u2 = \u1*sqrt(3);

\u3 = 0.5*\s;

sierpinski(\x,\y,\u3,\d-1);

sierpinski(\x+\u3,\y,\u3,\d-1);

sierpinski(\x+\u1,\y+\u2,\u3,\d-1);

};

};

% Let the length of the sides of the base triangle be 4, and generate 6 figures

\S = 4;

for \d in {0,...,5}{

% To situate all plots nicely under and next to each other, define the coords

% of the lower left corners preemptively

\x = (\S+1)*mod(\d,2);

\y = int(\d/2) * (\S+1);

sierpinski(\x,-\y,\S,\d);

};

}
```

```

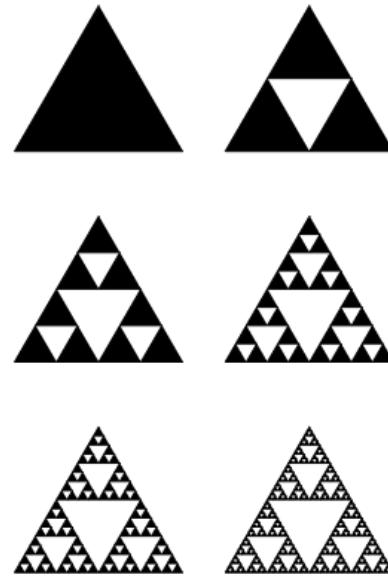
}
\end{tikzpicture}
\end{document}
```

T_EX thirteen.tex

```

12 \begin{document}
13 \begin{tikzpicture}
18 % Draw a triangle lower left
19 { \Triangle{(\x,\y)}{\s}; }
20 } else {
21 % Rescale the length of the
22 % for the next triangles
23 \u1 = 0.25*\s;
24 \u2 = \u1*sqrt(3);
25 \u3 = 0.5*\s;
26 sierpinski(\x,\y,\u3,\d-1);
27 sierpinski(\x+\u3,\y,\u3,\d
28 sierpinski(\x+\u1,\y+\u2,\u
29 };
30 };
31 % Let the length of the sid
32 \s = 4;
```

PDF thirteen.pdf



4 Выполнение лабораторной работы

4.1 8.2 Упражнения / Exercises

4.1.1 Упражнение 1: Создание графа / Exercise 1: Creating a Graph

```
\documentclass[border=1cm]{standalone}
\usepackage{tikz}
\begin{document}
\begin{tikzpicture}[scale=1.5]
% Define nodes with specified styles
\node[circle, draw, fill=green!50] at (0,0) (A) {A};
\node[rectangle, draw, fill=white] at (2,1) (B) {B};
\node[circle, draw, fill=green!50] at (4,0) (C) {C};
\node[rectangle, draw, fill=white] at (2,-1) (D) {D};
\node[circle, draw, fill=green!50] at (1,0.5) (E) {E};
```

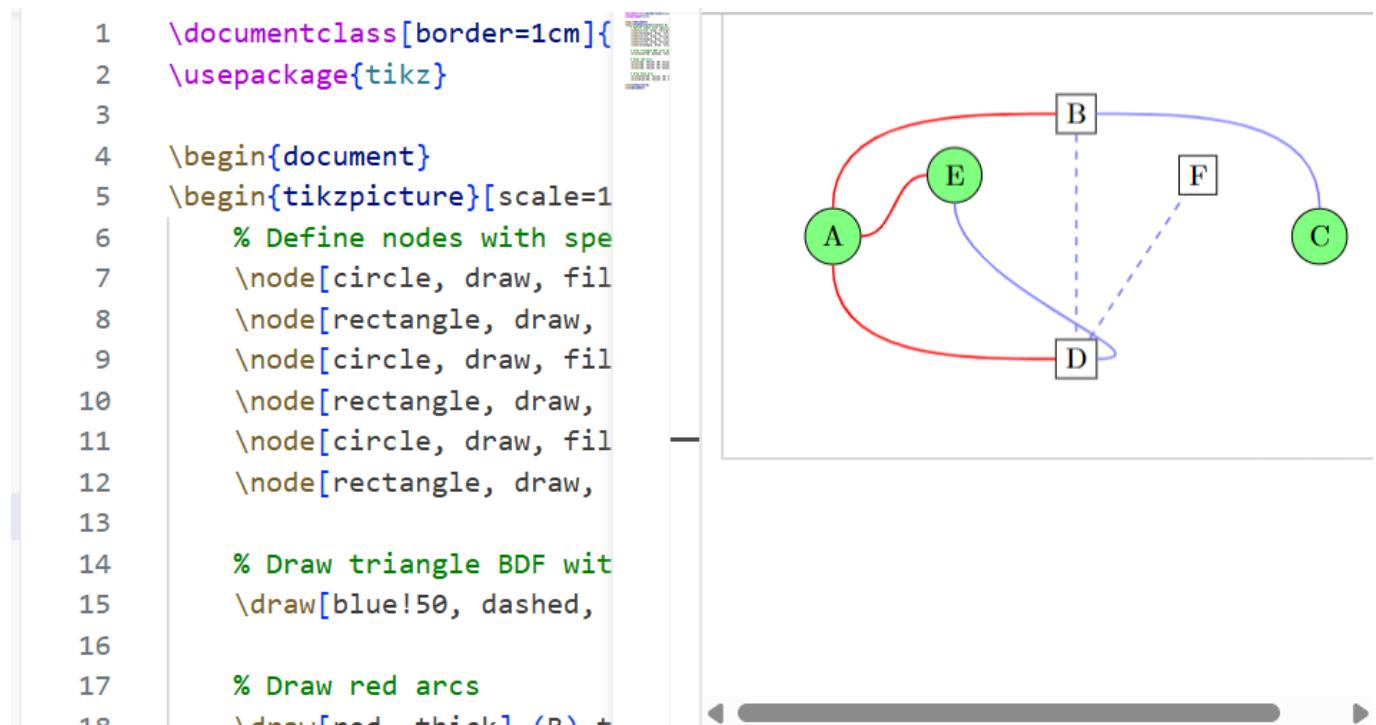
```
\node[rectangle, draw, fill=white] at (3,0.5) (F) {F};

% Draw triangle BDF with dashed light blue lines
\draw[blue!50, dashed, thick] (B) -- (D) -- (F) -- cycle;

% Draw red arcs
\draw[red, thick] (B) to[out=180, in=90] (A);
\draw[red, thick] (D) to[out=180, in=270] (A);
\draw[red, thick] (A) to[out=0, in=180] (E);

% Draw blue arcs
\draw[blue!50, thick] (B) to[out=0, in=90] (C);
\draw[blue!50, thick] (D) to[out=0, in=270] (E);

\end{tikzpicture}
\end{document}
```



4.1.2 Упражнение 2: Построение графиков функций / Exercise 2: Plotting Function Graphs

```
\documentclass[border=1cm]{standalone}

\usepackage{tikz}

\usepackage{amsmath}

\begin{document}

\begin{tikzpicture}[scale=1.2]
```

% Draw coordinate system

```
\draw[->, thick] (-0.5,0) -- (4.5,0) node[right] {$x$};  
\draw[->, thick] (0,-0.5) -- (0,4.5) node[above] {$y$};
```

% Draw grid

```
\draw[gray!30] (0,0) grid (4,4);
```

% Draw the curves

% Exponential function $y = e^x$

```
\draw[blue, thick, domain=0:1.4, samples=100] plot (\x, {exp(\x)});  
\node[blue, right] at (1.4, {exp(1.4)}) {$y = e^x$};
```

% Natural logarithm $y = \ln(x)$

```
\draw[red, thick, domain=0.37:4, samples=100] plot (\x, {ln(\x)});  
\node[red, above] at (3.5, {ln(3.5)}) {$y = \ln(x)$};
```

% Horizontal line $y = 1$

```
\draw[green, thick, dashed] (0,1) -- (4,1);  
\node[green, left] at (0,1) {$y = 1$};
```

% Vertical line $x = 1$

```
\draw[orange, thick, dashed] (1,0) -- (1,4);  
\node[orange, below] at (1,0) {$x = 1$};
```

% Mark intersection points

```
\fill[black] (0,1) circle (2pt);  
\fill[black] (1,0) circle (2pt);  
\fill[black] (1,1) circle (2pt);
```

% Add labels for intersection points

```
\node[below left] at (0,1) {$(0,1)$};  
\node[below right] at (1,0) {$(1,0)$};  
\node[above right] at (1,1) {$(1,1)$};
```

% Add title

```
\node[align=center] at (2,4.2) {\textbf{TikZ Graph Exercise}};
```

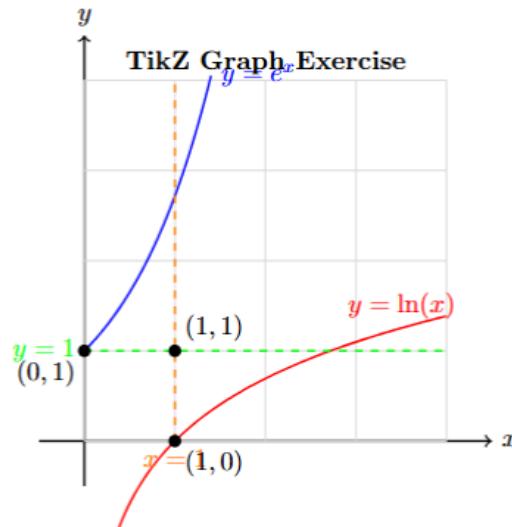
```
\end{tikzpicture}
```

```
\end{document}
```

```

1  \documentclass[border=1cm]{standalone}
2  \usepackage{tikz}
3  \usepackage{amsmath}
4
5  \begin{document}
6  \begin{tikzpicture}[scale=1
7      % Draw coordinate system
8      \draw[->, thick] (-0.5,
9      \draw[->, thick] (0,-0.
10
11    % Draw grid
12    \draw[gray!30] (0,0) gr
13
14    % Draw the curves
15    % Exponential function
16    \draw[blue, thick, doma
17    \node[blue, right] at (

```



4.1.3 Упражнение 3: Ковёр Серпинского / Exercise 3: Sierpiński Carpet

```

\documentclass[border=1cm]{standalone}

\usepackage{tikz}

% Function to draw Sierpiński carpet

\newcommand{\sierpinskicarpet}[4]{% x, y, size, level
\ifnum#4=0
\fill[black] (#1,#2) rectangle (#1+#3,#2+#3);
\else
\pgfmathsetmacro{\newsiz}{#3/3}
\edef\nextlevel{\the\numexpr#4-1\relax}
% Draw the 8 smaller carpets around the center hole
\sierpinskicarpet{#1}{#2}{\newsiz}{\nextlevel}% bottom-left
\sierpinskicarpet{#1+\newsiz}{#2}{\newsiz}{\nextlevel}% bottom-middle
\sierpinskicarpet{#1+2*\newsiz}{#2}{\newsiz}{\nextlevel}% bottom-right
\sierpinskicarpet{#1}{#2+\newsiz}{\newsiz}{\nextlevel}% middle-left

```

```
% Center is empty - this creates the characteristic hole  
\sierpinskicarpet{#1+2*\newscale}{#2+\newscale}{\newscale}{\nextlevel}% middle-right  
\sierpinskicarpet{#1}{#2+2*\newscale}{\newscale}{\nextlevel}% top-left  
\sierpinskicarpet{#1+\newscale}{#2+2*\newscale}{\newscale}{\nextlevel}% top-middle  
\sierpinskicarpet{#1+2*\newscale}{#2+2*\newscale}{\newscale}{\nextlevel}% top-right  
\fi  
}  
\begin{document}  
\begin{tikzpicture}  
% Draw carpets for iterations 0 to 3  
\foreach \i in {0,1,2,3} {  
  \begin{scope}[xshift=\i*4cm]  
    \draw[black, thick] (0,0) rectangle (3,3);  
    \sierpinskicarpet{0}{0}{3}{\i}  
    \node[below] at (1.5,-0.3) {Level \i};  
  \end{scope}  
}  
% Title  
\node[above] at (6,3.5) {Large Sierpiński Carpet};  
\end{tikzpicture}  
\end{document}
```

The screenshot shows a LaTeX editor interface with two panes. The left pane, titled 'TeX sixteen.tex', displays the following code:

```
1 \documentclass[border=1cm]{  
2      
3      
4    % Function to draw Sierpiński Carpet  
5    \newcommand{\sierpinskicarp}{  
6      \ifnum#4=0  
7        \fill[black] (#1,#2)  
8      \else  
9        \pgfmathsetmacro{\n}{  
10       \edef\nextlevel{\th{  
11         \dots  
12         % Draw the 8 smaller squares  
13         \sierpinskicarp{#1}{#2}{#3}{#4-1}  
14         \sierpinskicarp{#1}{#2}{#3+0.25}{#4-1}  
15         \sierpinskicarp{#1}{#2}{#3+0.5}{#4-1}  
16         \sierpinskicarp{#1}{#2}{#3+0.75}{#4-1}  
17         \sierpinskicarp{#1+0.25}{#2}{#3}{#4-1}  
18         % Center is empty  
19       }  
20     }  
21   }  
22 }  
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