MatematiCAL anal for economists

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Preface

This textbook is designed to assist economics students studying the basic course of mathematical analysis. It summarizes the entire mathematical analysis course taught to economists in the best undergraduate economics program in Eastern Europe.

The lectures include only the essential material, ensuring that students who have achieved top honors in national economics Olympiads are not overburdened and can maintain their sense of superiority over the rest of the world. After all, they likely mastered all this material in kindergarten (or at the latest, by first grade). The division of topics into lectures corresponds well to the actual pace of the course, which spans an entire semester. Almost all statements in the course are self-evident, and their proofs are left to the reader as straightforward exercises.

Contents

Chapter 1

Numbers

1.1 Basic Classes of Numbers

First, let's introduce the definitions of the basic classes of numbers that we will constantly work with throughout the course.

Definition 1 *Numbers 1, 2, 3, . . . are called natural numbers. The notation for the set of all natural numbers is* $\mathbb{N}$.

Definition 2 *A number is called an integer if it is equal to. . . but you don't need this because everything in economics is positive.*

Definition 3 *A number is called rational if it can be represented as something above a line and something below a line.*

Definition 4 *A number is called irrational if it is not rational.*

Obvious Fact 1 *The sum of all natural numbers equals* $-1/12$.

Kindergarten Example: If Vasya had 2 apples and Petya took 1 apple from him, how many apples does Vasya have left? The answer is obviously $-1/12$, as any advanced mathematician knows.

Chapter 2

Derivative

2.1 Basic derivatives

Definition 5 *The definition of derivative is omitted because it is obvious.*

Everything in this chapter is so obvious that no additional explanations will be provided - we'll immediately proceed to analyze an example from kindergarten. **Let's calculate a simple derivative:**

$$\sin(15 \cdot (\sin(x))^5) + 3 + \cos((20 \cdot x + 9)^3) \tag{2.1}$$

It is obvious that:

$$\frac{df}{dx}(\sin(x)) = \cos(x) \tag{2.2}$$

A good, solid task?

$$\frac{df}{dx}((\sin(x))^5) = \cos(x) \cdot 5 \cdot (\sin(x))^4 \tag{2.3}$$

Let's imagine this household as:

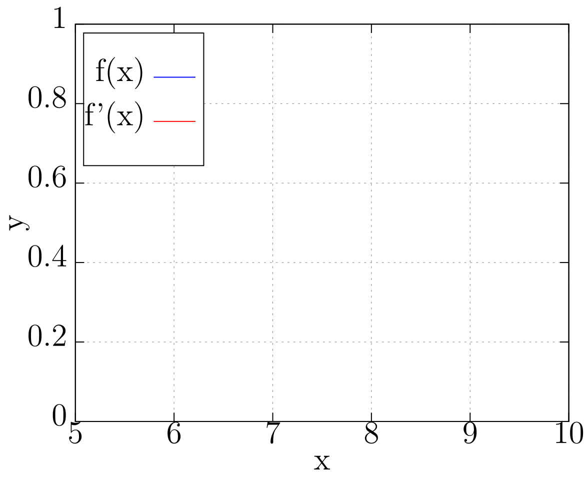
$$\frac{df}{dx}(15 \cdot (\sin(x))^5) = 15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \tag{2.4}$$

A good, solid task?

$$\frac{df}{dx}(\sin(15 \cdot (\sin(x))^5)) = 15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \cdot \cos(15 \cdot (\sin(x))^5) \tag{2.5}$$

As already shown earlier:

$$\frac{df}{dx}(\sin(15 \cdot (\sin(x))^5) + 3) = 15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \cdot \cos(15 \cdot (\sin(x))^5) \tag{2.6}$$



It is easy to see:

$$\frac{df}{dx}(20 \cdot x) = 20 \tag{2.7}$$

It is easy to see:

$$\frac{df}{dx}(20 \cdot x + 9) = 20 \tag{2.8}$$

It is obvious that:

$$\frac{df}{dx}((20 \cdot x + 9)^3) = 20 \cdot 3 \cdot (20 \cdot x + 9)^2 \tag{2.9}$$

Should be known from school:

$$\frac{df}{dx}(\cos((20 \cdot x + 9)^3)) = 20 \cdot 3 \cdot (20 \cdot x + 9)^2 \cdot -1 \cdot \sin((20 \cdot x + 9)^3) \tag{2.10}$$

As already shown earlier:

$$\begin{split}\frac{df}{dx}(\sin(15 \cdot (\sin(x))^5) + 3 + \cos((20 \cdot x + 9)^3))\\ = 15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \cdot \cos(15 \cdot (\sin(x))^5) + 20 \cdot 3 \cdot (20 \cdot x + 9)^2 \cdot -1 \cdot \sin((20 \cdot x + 9)^3)\end{split} \tag{2.11}$$

Let's calculate a simple derivative:

$$\begin{split}15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \cdot \cos(15 \cdot (\sin(x))^5)\\ + 20 \cdot 3 \cdot (20 \cdot x + 9)^2 \cdot -1 \cdot \sin((20 \cdot x + 9)^3)\end{split} \tag{2.12}$$

If this is not obvious to you, try attending a lecture for a change:

$$\frac{df}{dx}(\cos(x)) = -1 \cdot \sin(x) \tag{2.13}$$

It is obvious that:

$$\frac{df}{dx}(\sin(x)) = \cos(x) \tag{2.14}$$

According to the theorem (which number?) from paragraph ??:

$$\frac{df}{dx}((\sin(x))^4) = \cos(x) \cdot 4 \cdot (\sin(x))^3 \tag{2.15}$$

It is obvious that:

$$\frac{df}{dx}(5 \cdot (\sin(x))^4) = 5 \cdot \cos(x) \cdot 4 \cdot (\sin(x))^3 \tag{2.16}$$

Understanding this transformation is left to the reader as a simple exercise:

$$\frac{df}{dx}(\cos(x) \cdot 5 \cdot (\sin(x))^4) = -1 \cdot \sin(x) \cdot 5 \cdot (\sin(x))^4 + \cos(x) \cdot 5 \cdot \cos(x) \cdot 4 \cdot (\sin(x))^3 \tag{2.17}$$

A good, solid task?

$$\begin{split}\frac{df}{dx}(15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4) = 15 \cdot (-1 \cdot \sin(x) \cdot 5 \cdot (\sin(x))^4 + \cos(x) \cdot 5 \\ \cdot \cos(x) \cdot 4 \cdot (\sin(x))^3)\end{split} \tag{2.18}$$

Plus a constant:

$$\frac{df}{dx}(\sin(x)) = \cos(x) \tag{2.19}$$

If you don't understand this obvious transformation, then you need to go into a program where they don't study mathematical analys:

$$\frac{df}{dx}((\sin(x))^5) = \cos(x) \cdot 5 \cdot (\sin(x))^4 \tag{2.20}$$

It is obvious that:

$$\frac{df}{dx}(15 \cdot (\sin(x))^5) = 15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \tag{2.21}$$

It is obvious that:

$$\frac{df}{dx}(\cos(15 \cdot (\sin(x))^5)) = 15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \cdot -1 \cdot \sin(15 \cdot (\sin(x))^5) \tag{2.22}$$

If this is not obvious to you, try attending a lecture for a change:

$$\begin{split}&\frac{df}{dx}(15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \cdot \cos(15 \cdot (\sin(x))^5)) \\ &= 15 \cdot (-1 \cdot \sin(x) \cdot 5 \cdot (\sin(x))^4 + \cos(x) \cdot 5 \cdot \cos(x) \cdot 4 \cdot (\sin(x))^3) \cdot \cos(15 \cdot (\sin(x))^5) \\ &\quad + 15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \cdot 15 \cdot \cos(x) \cdot 5 \cdot (\sin(x))^4 \cdot -1 \cdot \sin(15 \cdot (\sin(x))^5)\end{split} \tag{2.23}$$

It is obvious that:

$$\frac{df}{dx}(20 \cdot x) = 20 \tag{2.24}$$

Should be known from school:

$$\frac{df}{dx}(20 \cdot x + 9) = 20 \tag{2.25}$$

Should be known from school:

$$\frac{df}{dx}((20 \cdot x + 9)^2) = 20 \cdot 2 \cdot (20 \cdot x + 9) \tag{2.26}$$

Understanding this transformation is left to the reader as a simple exercise:

$$\frac{df}{dx}(3 \cdot (20 \cdot x + 9)^2) = 3 \cdot 20 \cdot 2 \cdot (20 \cdot x + 9) \tag{2.27}$$

If you don't understand this obvious transformation, then you need to go into a program where they don't study mathematical analys:

$$\frac{df}{dx}(20 \cdot 3 \cdot (20 \cdot x + 9)^2) = 20 \cdot 3 \cdot 20 \cdot 2 \cdot (20 \cdot x + 9) \tag{2.28}$$

Understanding this transformation is left to the reader as a simple exercise:

$$\frac{df}{dx}(20 \cdot x) = 20 \tag{2.29}$$

A similar one can be proved:

$$\frac{df}{dx}(20 \cdot x + 9) = 20 \tag{2.30}$$

It is easy to see:

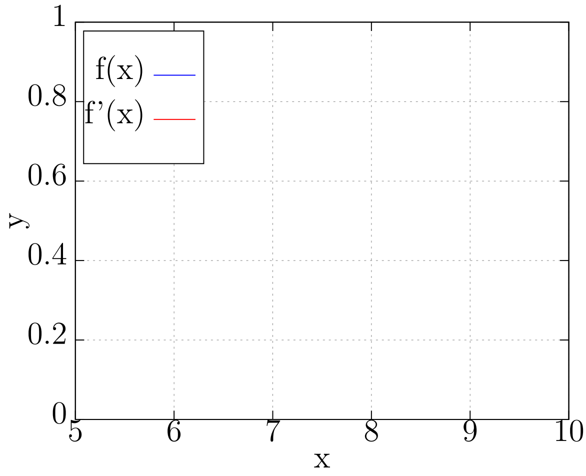
$$\frac{df}{dx}((20 \cdot x + 9)^3) = 20 \cdot 3 \cdot (20 \cdot x + 9)^2 \tag{2.31}$$

It is common knowledge:

$$\frac{df}{dx}(\sin((20 \cdot x + 9)^3)) = 20 \cdot 3 \cdot (20 \cdot x + 9)^2 \cdot \cos((20 \cdot x + 9)^3) \tag{2.32}$$

A good, solid task?

$$\frac{df}{dx}(-1 \cdot \sin((20 \cdot x + 9)^3)) = -1 \cdot 20 \cdot 3 \cdot (20 \cdot x + 9)^2 \cdot \cos((20 \cdot x + 9)^3) \tag{2.33}$$



As already shown earlier:

$$\begin{aligned}&\frac{df}{dx}(20\cdot 3\cdot(20\cdot x+9)^2\cdot -1\cdot\sin((20\cdot x+9)^3))\\&\quad=20\cdot 3\cdot 20\cdot 2\cdot(20\cdot x+9)\cdot -1\cdot\sin((20\cdot x+9)^3)+20\cdot 3\\&\qquad\cdot(20\cdot x+9)^2\cdot -1\cdot 20\cdot 3\cdot(20\cdot x+9)^2\cdot\cos((20\cdot x+9)^3)\end{aligned}\tag{2.34}$$

If this is not obvious to you, try attending a lecture for a change:

$$\begin{aligned}&\frac{df}{dx}(15\cdot\cos(x)\cdot 5\cdot(\sin(x))^4\cdot\cos(15\cdot(\sin(x))^5)+20\cdot 3\cdot(20\cdot x+9)^2\cdot -1\\&\quad\cdot\sin((20\cdot x+9)^3))=15\cdot(-1\cdot\sin(x)\cdot 5\cdot(\sin(x))^4+\cos(x)\cdot 5\cdot\cos(x)\cdot 4\cdot(\sin(x))^3)\\&\qquad\cdot\cos(15\cdot(\sin(x))^5)+15\cdot\cos(x)\cdot 5\cdot(\sin(x))^4\cdot 15\cdot\cos(x)\cdot 5\cdot(\sin(x))^4\cdot -1\\&\qquad\cdot\sin(15\cdot(\sin(x))^5)+20\cdot 3\cdot 20\cdot 2\cdot(20\cdot x+9)\cdot -1\cdot\sin((20\cdot x+9)^3)\\&\qquad+20\cdot 3\cdot(20\cdot x+9)^2\cdot -1\cdot 20\cdot 3\cdot(20\cdot x+9)^2\cdot\cos((20\cdot x+9)^3)\end{aligned}\tag{2.35}$$

Chapter 3

Taylor

3.1 Taylor's formula with the remainder term (and why is it needed? Without it, everything is obvious)

Definition 6 *Taylor's formula is obvious, so no additional explanations will be given. Let's start straight with an example.*

At first the derivatives must be calcutated:

Let's calculate a simple derivative:

$$\cos(\sin(x)) + x^3 \tag{3.1}$$

It is common knowledge:

$$\frac{df}{dx}(\sin(x)) = \cos(x) \tag{3.2}$$

A similar one can be proved:

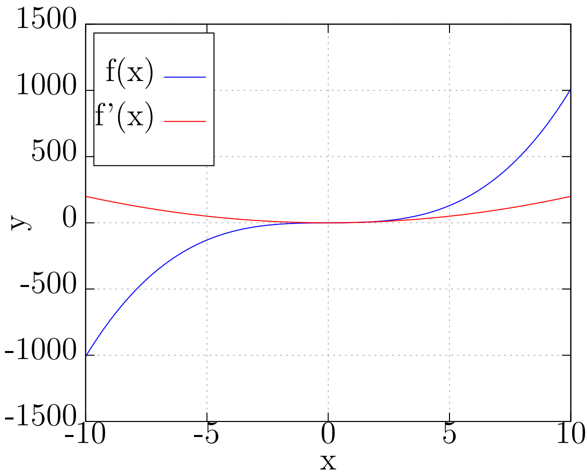
$$\frac{df}{dx}(\cos(\sin(x))) = \cos(x) \cdot -1 \cdot \sin(\sin(x)) \tag{3.3}$$

Plus a constant:

$$\frac{df}{dx}(x^3) = 3 \cdot x^2 \tag{3.4}$$

If you don't understand this obvious transformation, then you need to go into a program where they don't study mathematical analys:

$$\frac{df}{dx}(\cos(\sin(x)) + x^3) = \cos(x) \cdot -1 \cdot \sin(\sin(x)) + 3 \cdot x^2 \tag{3.5}$$



Let's calculate a simple derivative:

$$\cos(x) \cdot -1 \cdot \sin(\sin(x)) + 3 \cdot x^2 \tag{3.6}$$

According to the theorem (which number?) from paragraph ??:

$$\frac{df}{dx}(\cos(x)) = -1 \cdot \sin(x) \tag{3.7}$$

A good, solid task?

$$\frac{df}{dx}(\sin(x)) = \cos(x) \tag{3.8}$$

Let's imagine this household as:

$$\frac{df}{dx}(\sin(\sin(x))) = \cos(x) \cdot \cos(\sin(x)) \tag{3.9}$$

Understanding this transformation is left to the reader as a simple exercise:

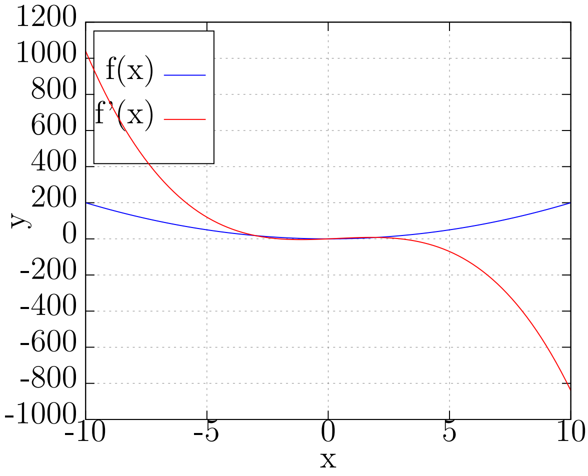
$$\frac{df}{dx}(-1 \cdot \sin(\sin(x))) = -1 \cdot \cos(x) \cdot \cos(\sin(x)) \tag{3.10}$$

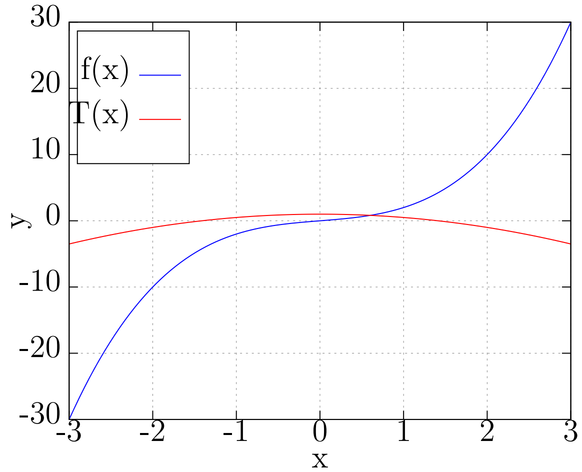
Plus a constant:

$$\begin{aligned}\frac{df}{dx}(\cos(x) \cdot -1 \cdot \sin(\sin(x))) = {} & -1 \cdot \sin(x) \cdot -1 \cdot \sin(\sin(x)) \\ & + \cos(x) \cdot -1 \cdot \cos(x) \cdot \cos(\sin(x))\end{aligned} \tag{3.11}$$

A good, solid task?

$$\frac{df}{dx}(x^2) = 2 \cdot x \tag{3.12}$$





A good, solid task?

$$\frac{df}{dx}(3 \cdot x^2) = 3 \cdot 2 \cdot x \tag{3.13}$$

If this is not obvious to you, try attending a lecture for a change:

$$\begin{aligned}\frac{df}{dx}(\cos(x) \cdot -1 \cdot \sin(\sin(x)) + 3 \cdot x^2) = -1 \cdot \sin(x) \cdot -1 \cdot \sin(\sin(x)) + \cos(x) \\ \cdot -1 \cdot \cos(x) \cdot \cos(\sin(x)) + 3 \cdot 2 \cdot x\end{aligned} \tag{3.14}$$

Taylor Series:

$$T(\cos(\sin(x)) + x^3) = 1 + -0.5 \cdot x^2 ... \tag{3.15}$$

Afterword

Dear readers, I hope you have been able to spare a moment of your attention for this textbook and to realize its incredible obviousness. You will now excel in your exam, and if not, good luck next year.

The author also expresses great gratitude for the help in preparing this textbook to the students and professors of MIPT, namely to DED, mentor Kolya, and co-mentor Artyom, for actively seeking out the cringe in the code, which undoubtedly improved the quality of the materials. For this important work, the author wholeheartedly thanks all the assistants.

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