

## Tutorial Sheet: Multivariable Calculus

1. Examine if the limits as  $(x, y) \rightarrow (0, 0)$  exist?

$$(a) \begin{cases} \frac{x^2 y^2}{x^2 + y^2} & x \neq y \\ 0 & x = y \end{cases} \quad (b) \ xy \left( \frac{x^2 - y^2}{x^2 + y^2} \right) \quad (c) \begin{cases} x \sin \frac{1}{x} + y \sin \frac{1}{y} & xy \neq 0 \\ 0 & xy = 0 \end{cases}$$

$$(d) \frac{\sin(xy)}{x^2 + y^2}$$

2. Examine the continuity of the following functions

$$(a) \begin{cases} \frac{xy^2}{x^2 + y^2} & (x, y) \neq (0, 0) \\ 0 & \text{otherwise} \end{cases} \quad (b) \begin{cases} x^2 + y^2, & x^2 + y^2 \leq 1 \\ 0, & \text{otherwise} \end{cases}$$

$$(c) \begin{cases} \frac{\sin^2(x - y)}{|x| + |y|} & (x, y) \neq (0, 0) \\ 0 & \text{otherwise} \end{cases} \quad (d) \begin{cases} \frac{x^2 y^2}{x^2 y^2 + (x - y)^2} & (x, y) \neq (0, 0) \\ 0 & \text{otherwise} \end{cases}$$

3. Discuss the differentiability of the following functions at  $(0, 0)$

$$(a) f(x, y) = \begin{cases} x \sin \frac{1}{x} + y \sin \frac{1}{y} & xy \neq 0 \\ \sin y & xy = 0 \end{cases} \quad (b) \begin{cases} \frac{\sqrt{x^2 + y^2}}{\sqrt{x^2 + y^2}} & x^2 + y^2 \neq 0 \\ 0 & x = y = 0 \end{cases}$$

$$(c) \begin{cases} \frac{x^2 y^2}{x^2 + y^2} & x^2 + y^2 \neq 0 \\ 0 & x = 0, y = 0 \end{cases}$$

4. Let  $f(x, y) = \frac{1}{|y|} \sqrt{x^2 + y^2}$ ,  $y \neq 0$  and  $f(x, 0) = 0$ . Show that  $f$  has all directional derivatives at  $(0, 0)$  but it is not differentiable at  $(0, 0)$ .

5. Let  $f(x, y) = |x| - |y|$ . Is  $f$  continuous at  $(0, 0)$ ? Which directional derivatives exist at  $(0, 0)$ ? (The answer is no.)

# Tutorial Calculus Multivariable

**Yi-Tong Ma**



## **Tutorial Calculus Multivariable:**

This book delves into Tutorial Calculus Multivariable. Tutorial Calculus Multivariable is a vital topic that must be grasped by everyone, ranging from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into Tutorial Calculus Multivariable, encompassing both the fundamentals and more intricate discussions.

1. This book is structured into several chapters, namely:
  - Chapter 1: Introduction to Tutorial Calculus Multivariable
  - Chapter 2: Essential Elements of Tutorial Calculus Multivariable
  - Chapter 3: Tutorial Calculus Multivariable in Everyday Life
  - Chapter 4: Tutorial Calculus Multivariable in Specific Contexts
  - Chapter 5: Conclusion
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3. In chapter 2, this book will delve into the foundational concepts of Tutorial Calculus Multivariable. The second chapter will elucidate the essential principles that need to be understood to grasp Tutorial Calculus Multivariable in its entirety.
4. In chapter 3, this book will examine the practical applications of Tutorial Calculus Multivariable in daily life. This chapter will showcase real-world examples of how Tutorial Calculus Multivariable can be effectively utilized in everyday scenarios.
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6. In chapter 5, this book will draw a conclusion about Tutorial Calculus Multivariable. This chapter will summarize the key points that have been discussed throughout the book.

This book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of Tutorial Calculus Multivariable.

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