Tutorial Sheet:Multivariable Calculus

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

(a) $\begin{cases} \frac{x^2 y}{x^4 + y^2} & x \neq y \\ 0 & x = y \end{cases}$ (b) $xy\left(\dfrac{x^2 - y^2}{x^2 + y^2}\right)$ (c) $\begin{cases} x\sin\dfrac{1}{y} + y\sin\dfrac{1}{x} & xy \neq 0 \\ 0 & xy = 0 \end{cases}$

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

2. Examine the continuity of the following functions

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

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

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

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

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

4. Let $f(x,y) = \dfrac{xy}{|y|}\sqrt{x^2 + y^2}$, $y \neq 0$ 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 $f(x,y) = \left| |x| - |y| \right| - |x| - |y|$. Is f continuous at $(0,0)$? Which directional derivatives

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Camilla Rothe

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